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DAIRY WASTE MANAGEMENT

CERRITOS, CALIFORNIA

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

1973

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This report details defining and evaluating the major environmental problems in managing solid wastes produced by high-density cow housing located in close proximity to residential developments. Evaluation of the various types of cow housing and solid waste management facilities, from the viewpoint of environmental and economic acceptability. Economic and environmental evaluations of the various systems for utilization or disposal of dairy wastes. Development of methods and systems which will minimize fly production, odors, and drainage problems from earth corral dairies, especially in wet weather. Develop a process for economically and efficiently composting manure on each dairy.

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The project described in this report represents a truly cooperative effort of many agencies and individuals. The functions of some of the principal participants are shown in the following organizational chart and summary statement of tasks.

The principal committees and groups were:

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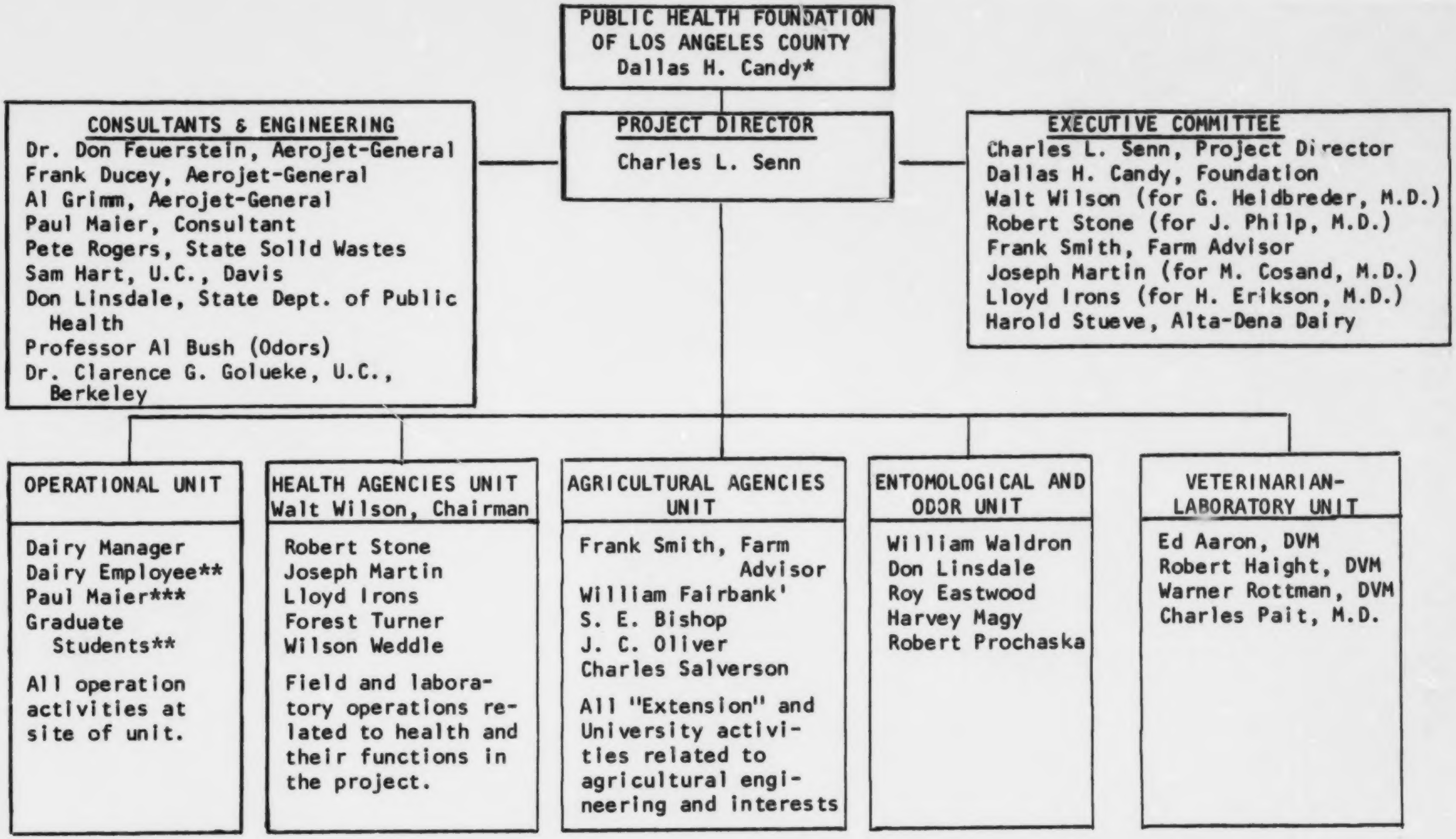
DAIRY WASTE MANAGEMENT PROJECT



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**Part time employees

***Consultant in control, operation and evaluation

DAIRY WASTE MANAGEMENT PROJECT

Time Schedule

	Task	Responsible Agent	1969		1970											
			Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Build & equip bins	Aerojet & Maier		—	—	—										
2	Operate bins	Alta-Dena Dairy, Senn & Maier				—	—	—	—	—	—	—	—			
3	Test product	Health Department Farm Advisor				—	—	—	—	—	—	—	—			
4	Complete ranking	Aerojet					—	—	—	—						
5	Environmental evaluation	Orange County H D* & other H D's				—	—	—	—	—	—	—				
6	Time cost effects:															
	a) Earth corrals	Alta-Dena Dairy, H D - F A**				—	—	—	—	—	—	—	—	—		
	b) Mechanically cleaned concrete	Alta-Dena Dairy, H D - F A				—	—	—	—	—	—	—	—	—		
	c) Water flushed concrete	Haflinger, H D, Farm Advisor				—	—	—	—	—	—	—	—	—		
7	Cow health & productivity	Veterinarians			—	—	—	—	—	—						
8	Vectors & odor evaluation	Entomology team & consultants						—	—	—	—	—	—			
9	Drainage	Farm Advisor, H D & Water Quality Brd		—	—	—	—	—	—							
10	Water usage	H D - F A Dairymen & Senn						—	—	—	—	—				
11	Waste water treatment & disposal	H D & Project Director				—	—	—	—	—	—	—	—			
12	Shaker screen evaluation	F A - H D & Senn				—	—	—	—	—	—	—	—			
13	Cow "maternity" facilities and "Q" fever	Veterinarians F A - H D Dairymen				—	—	—	—	—	—					
14	Weed-seed studies	Soil Lab & Univ				—	—	—	—	—	—					
15	Product evaluation	F A - University & Soil Laboratory				—	—	—	—	—	—	—				
16	Reporting	All Units & Project Director	—	—	continuous	—	—	—	—	—	—	—	—	—	—	—

* Health Department

** Farm Advisor

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Mr. Eugene M. Herson
Mr. Charles Orr
Mr. Kent Anderson
Mr. J. Robert Halloway

Graduate Student Participants:

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Dr. Min Sisk Park

Particular recognition is given to Mr. Frank Smith, Farm Advisor of Los Angeles County who devoted many hours aiding, guiding, and advising on the project, who performed education within the dairy industry on project goals and accomplishments, and acted as liaison representative with the University of California Extension Service and the Riverside Campus.

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DAIRY WASTE MANAGEMENT

Charles L. Senn

CHAPTER 1

INTRODUCTION

Background and Objectives

High-density cow housing is rapidly replacing traditional "dairy farms." To be near the market and sources of labor and supplies, the dairies tend to be concentrated in certain areas when these are close to large cities. There is, therefore, a natural tendency for the dairies to be in close proximity to residential developments.

This demonstration project began with the objectives of:

1. Defining and evaluating the major environmental problems in managing solid wastes produced by high-density cow housing located in close proximity to residential developments.
2. Evaluation of the various types of cow housing and solid waste management facilities, from the viewpoint of environmental and economic acceptability.
3. Economic and environmental evaluations of the various systems for utilization or disposal of dairy wastes.
4. Development of methods and systems which will minimize fly production, odors, and drainage problems from earth corral dairies, especially in wet weather.
5. Develop a process for economically and efficiently composting manure on each dairy.

As the project developed, new legislation and new pollution control policies necessitated inclusion of the following additional objectives:

1. What methods are most practical to avoid pollution of surface waters and nuisances by drainage from conventional corrals?
2. How can high-density cow housing be managed to avoid pollution of underground water supplies, when located on permeable soils above such aquifers?

Summary of First Phase of Project

The first phase of the project is briefly summarized here. A more complete report was previously prepared.

Project Sponsors and Participants. The city of Cerritos, in which there were over 20 relatively large dairies, sponsored and supported the project. The Dairymen's Fertilizer Cooperative, which was collecting, stock-piling, and marketing manure, provided the site, facilities, material, data, and operating personnel for the first phase.

The Aerojet General Corporation was the principal consultant and performed market analyses, economic analyses of various candidate systems, and ranking of anticipated environmental effects of such systems.

The project was supported and guided by a group of public agencies including the Farm Advisors, health departments of four counties surrounding Los Angeles, State Department of Public Health, and the University of California's Extension Service and Riverside Campus.

Project Consultants were Dr. Clarence G. Guelke, Professor Sam Hart, and Mr. Paul Maier.

Project Planning. Prior to the beginning of the project a court suit charged the Dairymen's Fertilizer Cooperative with creating nuisances and health hazards from dust generated by handling and processing manure (Figure 1). The charges were reviewed with health officers, epidemiologists, and environmentalists who joined in sponsoring the project. The group of participants agreed that the alleged "health problems" and nuisances should be resolved by avoiding the creation of a huge, central manure storing and processing operation. They decided that if health hazards from manure dust do exist, control should begin on the dairies. They decided that top priority should be given to processing the manure on each dairy by methods which would permit handling wet manure in wet weather, thereby helping to cope with the worst fly and odor problems which result when the winter's manure accumulations remain on earth corrals until dry enough for aging in the huge stockpile.

The City Council and the Cooperative's Board of Directors strongly favored to "utilize," rather than "dispose" of the manure. It was decided that the processing, preparing for sale and marketing might best be accomplished by a central cooperative organization which would serve many dairies by providing technical direction, specialized equipment, and marketing service. The project became a truly cooperative venture with teams covering various special subjects such as "Entomology and Odors," "Neighborhood Attitude Studies," "Veterinarian and Epidemiology," "Farm Advisors," etc.

The Aerojet General Corporation's marketing analysis showed that in the six county marketing area, at present, the manure from 60,000 cows is being sold as bulk or sacked "steer manure." Their studies included a comparative analysis of costs per cow per year of various possible processing, utilization,

Figure 1. 100,000 cubic yard manure "anaerobic composting pile."

and disposal methods. The economic aspects were considered along with the anticipated "environmental effects" of each method. The study included not only earth corrals, but also covered all-paved corrals, both water-flushed and mechanically cleaned. Their cost analysis was summarized as follows:

TABLE 1

COMPARATIVE ANALYSIS OF COSTS PER COW PER YEAR

System	Cost/Cow/Year
1. Earth corrals with manure composted on each dairy.	
a. Composted in aeration bins	$28*
b. Windrow composting by special machine	$40*
2. Paved corrals.	
a. Liquid flush-irrigate with waste	$21
b. Liquid flush-separate solids-irrigate	$22
c. Mechanically scrape-direct land utilization	$34
d. Scrape and compost by aeration	$28
e. Aerobic, liquid stabilization	$44
3. Collection of raw manure for centralized processing.	
a. Stockpile to "compost"	$19*
b. Aerated central composting	$25*
c. Central-mechanically turned windrowing	$29 to $69*
d. Heat drying	$49*
e. Incineration	$79*
f. Pyrolysis	$57*
g. Wet oxidation (Zimpro process)	$48+*

*Includes $7.80 per cow per year for harvesting from corrals and loading onto trucks.

The environmental "raters" were sanitarians, entomologists, farm advisors, and city officials. The rating scale was "0" for no effects to "9" for major effects. They each considered the three prevailing climatic conditions and found the following concerns:

1. Dry summer--principally dust with lesser concern about flies, odors, and drainage.
2. Wet winter--the season of least complaints with some concern for drainage.
3. Warm spring before winter manure accumulation is dried or removed--major problems are flies (ranked "9"), odor (ranked "8").

Neighborhood opinion sampling was conducted by a separate evaluation system designed by Orange County's Environmental Health Director and his staff, and utilized by both his staff and by personnel of the San Bernardino County Health Department, to measure attitudes of people living within various distances of dairies and in various locations with respect to prevailing winds. Nearly all householders living adjacent to corrals were concerned and dissatisfied. Those 350 feet away were influenced by the quality of dairy design and maintenance; and, those at 700 feet were unaware of the dairy unless it was visible across open fields. (Full report is in Appendix 1).

Environmental and Economic Assessment of Various Systems. Early in the project it was decided that this study would be principally concerned with dairies of limited area in locations which are becoming somewhat residential in character. This would tend to exclude dairies on large farms where raw manure can be applied directly to crop lands. It would also tend to exclude water-flushed systems which may be acceptable on large, irrigated farms where manure can be flushed with irrigation water for direct application on the land. (See comparative entomology report, Appendix 2).

Earth Corrals. The public attitude survey and environmental ranking systems showed that earth corral dairies are basically unacceptable neighbors to residents living within 350 feet. It was also noted that new water pollution control policies may lead to "outlawing" earth corrals where they produce either surface or ground water pollution. A long range prediction, based upon the study, is that earth corral dairies are becoming both environmentally and economically unacceptable in areas of mixed residential and agricultural uses and where land costs are too high to permit direct agricultural utilization of solid and liquid wastes. They will also be unacceptable where serious surface of ground water pollution results. (Figure 2)

Water-Flushed, All-concrete Housing. Theoretically the water-flushed dairy has many advantages. Some have claimed that the water already used for cooling, washing and cleaning milking parlors is simply reused for flushing the 15-foot-wide, several hundred foot-long, sloping (2-3%) area between free-stalls and feeding and watering facilities (Figure 3). Project studies and observations at three dairies with 400, 700, and 1200 cows showed this system requires up to two and a half times as much water as would have to be used for washing cows and milk parlors.

A major problem is how to utilize and dispose of this highly polluted water produced by dairies of limited land area, without producing surface and ground water pollution and nuisances. A secondary question is the somewhat controversial question of whether the wet concrete does produce a serious

Figure 2. Typical method of cleaning earth corrals in dry weather.

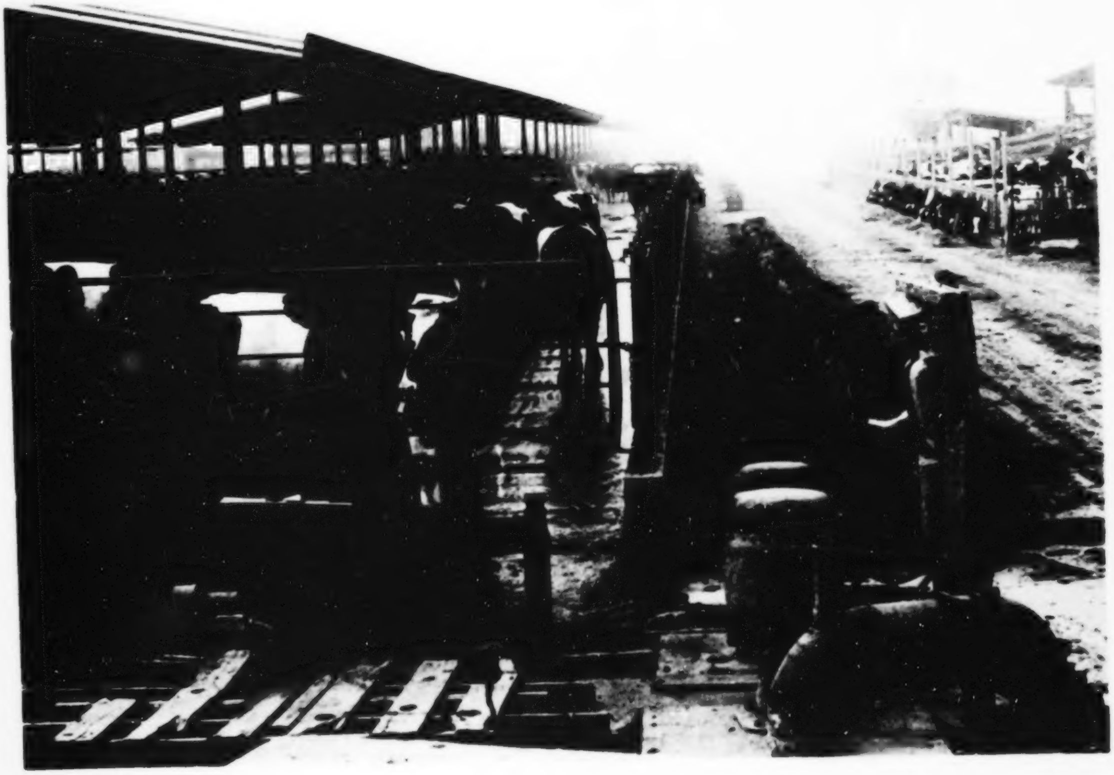

Figure 3. Typical water-flushed, free-stall dairy.

problem of cows' feet becoming sore. The project study indicates that at several dairies where this system is used, sore feet did not cause serious problems. Also, at all-concrete corrals, mastitis rates did not go up and milk production rates were maintained at times when production was down for cows housed on wet, muddy earth corrals. On the other hand, mastitis rates did go up among those cows which had to wade through mud-manure mixtures.

Among the possible, partial solutions to problems from water-flushed systems are:

1. Use of extended aeration to produce an affluent which can be recycled for certain cleaning functions; and which will produce an effluent acceptable for surface channel or ditch disposal during rainy weather.
2. Grouping of dairies to make it possible to build a "community" dairy waste sewerage and waste-water treatment system. Special problems may then exist, or extra treatment may be necessary, in situations where phosphates and nitrates may promote eutrophication of lakes and reservoirs, or where nitrates would contaminate water supplies.

Mechanically Cleaned, All-concrete, Roofed Housing. Project participants and consultants recommend that major emphasis be given to a system which will minimize the quantity and pollutional quality of waste-water and which will permit high-density housing with a minimum of adverse environmental effects. This involved:

1. Development of economical and non-nuisance producing manure processing methods.
2. Roofing and paving cow housing to avoid surface and ground water pollution.

3. Distribution of the compost for utilization by plants, lawns, and crops.

Composting Methods. Bench-scale testing in 6 - 6 cubic yard bins (Figure 4) at the site of the Dairymen's Fertilizer Cooperative demonstrated that composting by mechanical turning and agitation is inefficient and involves excessive labor.

On the other hand, efficient and effective composting is accomplished by introducing air into the manure by low-pressure blowers discharging through perforated pipes in the bottom of the material. By controlling the airflow rate the temperature can be maintained between 140 F and 170 F. Tests and observations by the project's entomology team and by agricultural specialists of the University of California showed the product did not attract flies nor produce fly larvae, even though subsequently moistened. It was found to be weed-seed free, nearly odorless, and free of pathogens. When screened, it was an attractive soil amendment that was easy-to-apply to lawns and gardens.

Figure 4. Bench-scale bin system.

CHAPTER 2

BIN COMPOSTING DEMONSTRATION

The bench-scale composting demonstration, market analysis, and environmental ranking all indicated that aerobic composting, at each dairy, is the most promising system for managing cow manure under the following conditions:

1. When it is not economical to beneficially apply manure directly on agricultural land
2. Where there is a market which enables recovery of a significant portion of the processing cost.

To obtain more comprehensive data on design, operation, economics, and other factors, the project was continued into a second phase. The participants were changed somewhat, as follows:

1. The city of Cerritos, with remarkable speed, changed from a "dairy community" to a "residential community," and withdrew active participation except for a continuing financial contribution.

2. The Dairymen's Fertilizer Cooperative site was sold to become part of a regional park.

3. With completion of the assigned responsibilities, Aerojet General gradually withdrew.

4. Farm Advisor and San Bernardino County Health Department participation became more active.

5. A most important point was that Alta-Dena Dairy, in the City of Industry offered to provide the site and much of the equipment and facilities for a full-scale demonstration of composting and sacking manure from 400 cows

on earth corrals. At that dairy there are over 2,000 cows. Sixteen-hundred were on earth corrals (Figure 5), and 400 in all-concrete, free-stall housing (Figure 6).

In addition to demonstrating composting of material from earth corrals, the project design provided for comparative evaluation of managing and composting manure-urine material being mechanically removed from the all-concrete housing. This was in support of the project consultant and committee recommendations that effort be made to avoid creating large volumes of polluted water, as is the case with water-flushed, all-concrete facilities.

Design Details

Figure 7 shows the arrangement of the composting facilities at the Alta-Dena Dairy in the City of Industry, Los Angeles County. The original facility included the composting bins and blowers shown in Figure 8. This was designed to process the manure from a 400 cow, earth corral dairy. The design factors were established by the first year study and bench-scale test program.

Composting Bins.

Composting time: maximum of two to seven-day periods of aerated composting.

Aging: minimum of 30 days of aging in stockpiles.

Quantity: 3/4-cubic feet of corral scrapings per cow per day.

Bin size: Each of the bins is designed to hold a week's corral scrapings from 400 cows, or 300 cubic feet per bin (111 cubic yards). The bins were made slightly larger so as to accomodate 133 cubic yards, if necessary.

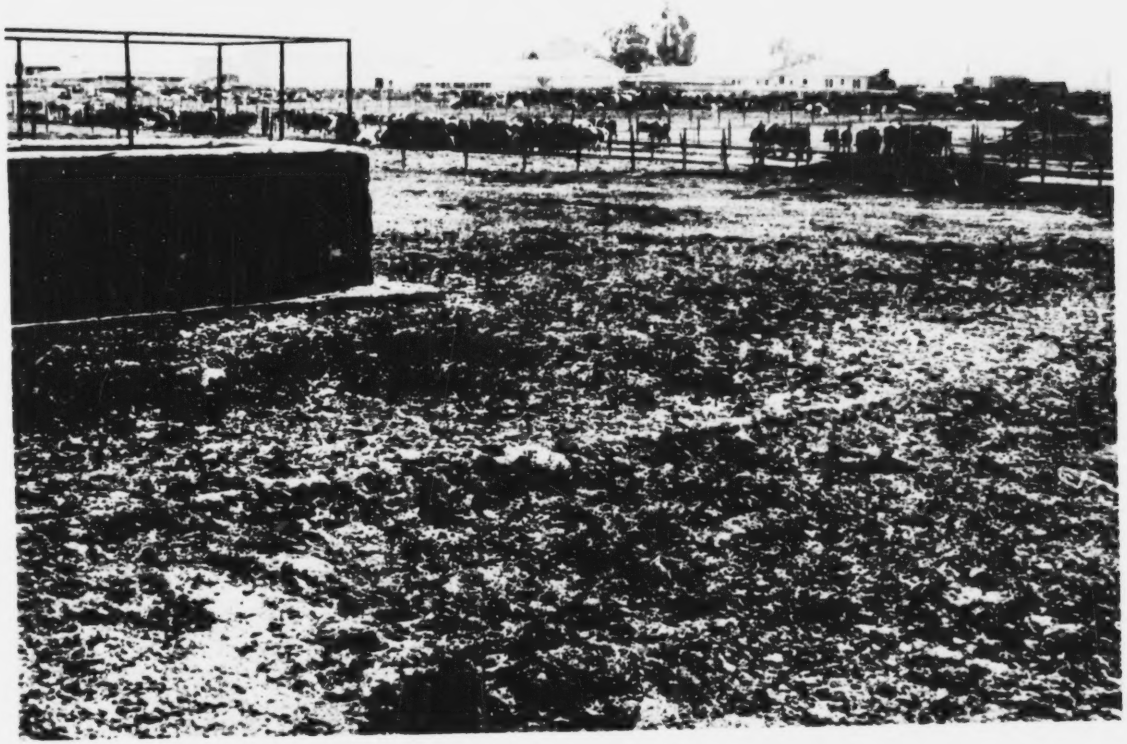

Figure 5. Earth corrals at Alta-Dena Dairy.

Figure 6. Mechanically cleaned free-stall units at Alta-Dena Dairy.

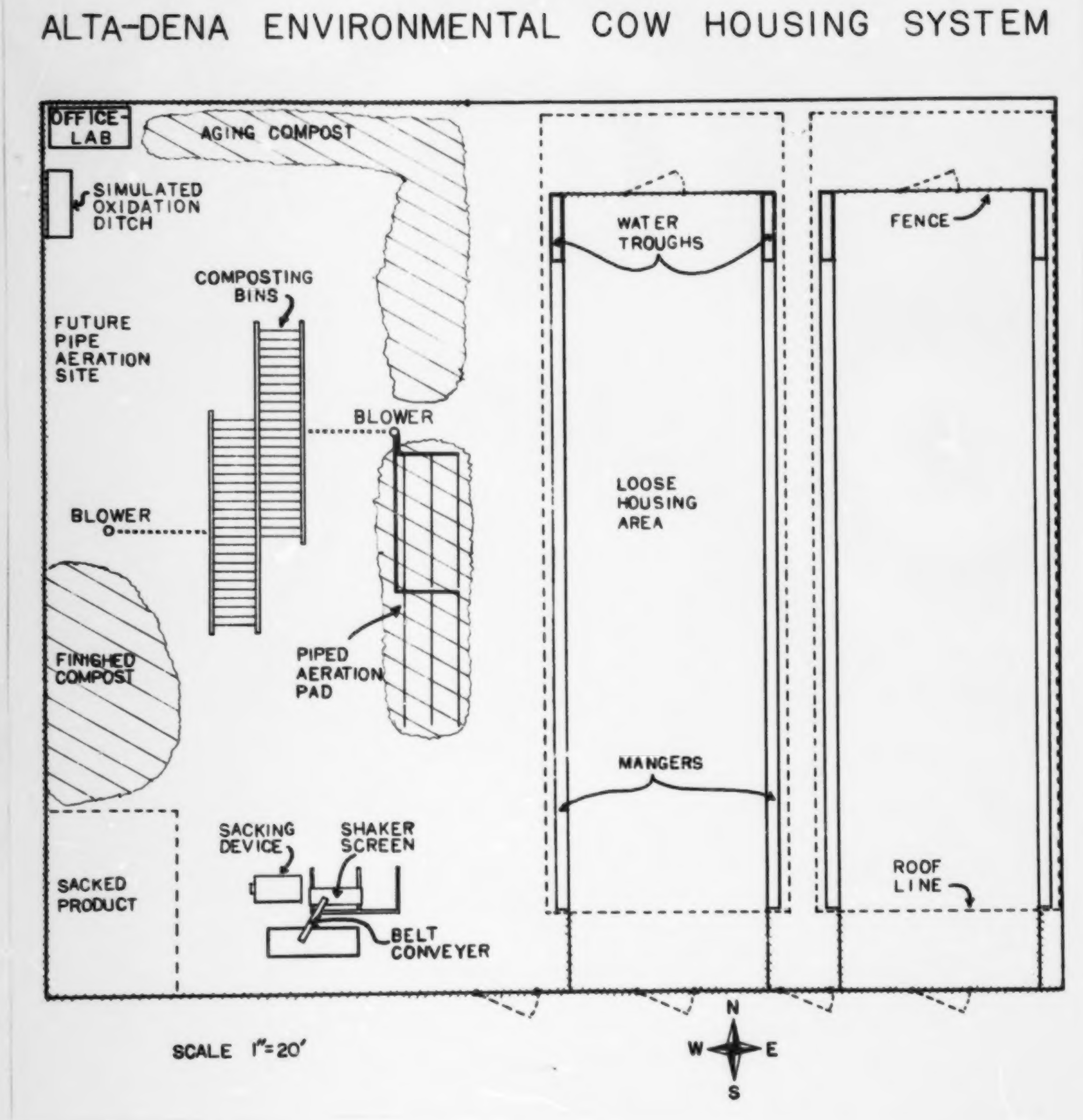

Figure 7. Arrangement of "environmental housing" and composting facility.

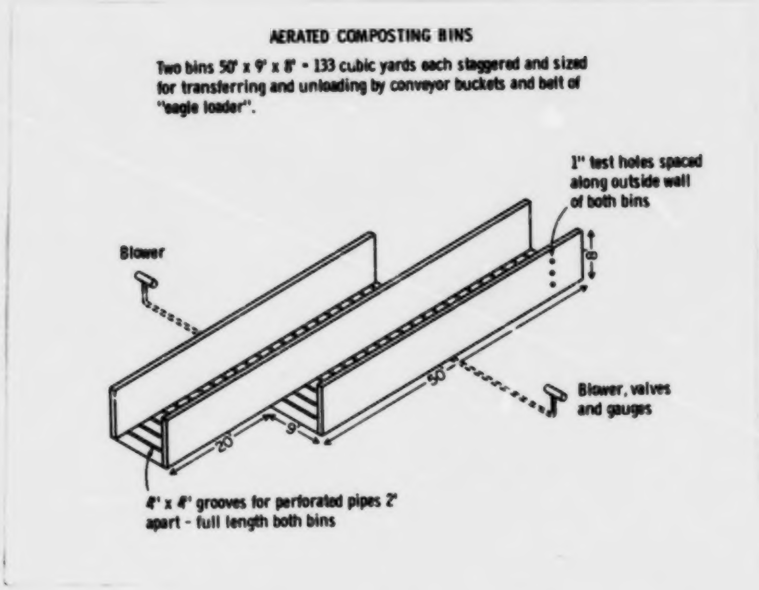
AERATED COMPOSTING BINS
Two bins 50' x 9' x 8' - 133 cubic yards each staggered and sized for transferring and unloading by conveyor buckets and belt of "eagle loader".
1" test holes spaced along outside wall of both bins
Blower
8
50
Blower, valves and gauges
9
20
4" x 4" grooves for perforated pipes 2' apart - full length both bins

Figure 8, Aerated composting bins.

Design for Manure Mixing and Handling. The National Canner's Association had used for a composting demonstration project, a unit primarily designed for loading sand and gravel. It is an Eagle Loader mounted on the rear of a 1½-ton International truck (Figure 9). The unit is backed into the material to be moved. Operating controls are located on the side of the unit so the operator can rather accurately operate the unit and its discharging belt conveyor. A corkscrew device at the rear moves material laterally to a center-mounted elevating bucket conveyor. This unit covers a width of 8 feet so the bins were made 9 feet wide. The buckets discharge to a belt conveyor which discharges at about 10 feet above the ground. This can be turned to any angle within 180 degrees.

Figure 9. Dairy owner, EPA official, and Health Officer at Eagle Loader.

The Eagle Loader conveyor belt discharges over the cab of the truck, and loads several feet behind the truck, so there is a distance of 20 feet from the point of loading to unloading. The bins were therefore staggered by 20 feet.

To confine the manure in the bins, hinged doors were originally provided but were later found to be relatively unnecessary, and were removed.

Blower System. The bench-scale operation indicated that the airflow rate must be highest at the beginning of the composting cycle and then gradually reduced. Normal maximum rates were 3 cubic feet per minute per cubic yard of manure, and the highest rates were 5 cubic feet of manure per cubic yard. Maximum static pressures were 6 inches water gauge.

Two blowers, each with a capacity of 500 cubic feet per minute against 6-inch w.g. pressure were installed so they could be used separately or together to aerate either or both bins. Each has a 1/3-horsepower motor, is multi-staged, and ran continuously for over a year with no maintenance or repair. Piping was designed for air velocities between 2,400 and 6,000 feet per minute, and to permit using different flow rates for each of the three separate systems serving each bin. All piping was P.V.C. Four-inch plug type valves were provided to regulate the airflow. Each line was supplied with an indicating static pressure gauge and an opening to measure velocities with a pitot tube (Figures 10 and 11).

Air Inlets. The bin floors were paved and provided with 4-inch-wide and 4-inch-deep lateral grooves, spaced 2 feet apart. One-inch plastic pipes with two 5/16-inch holes per foot were laid in the grooves. Openings through

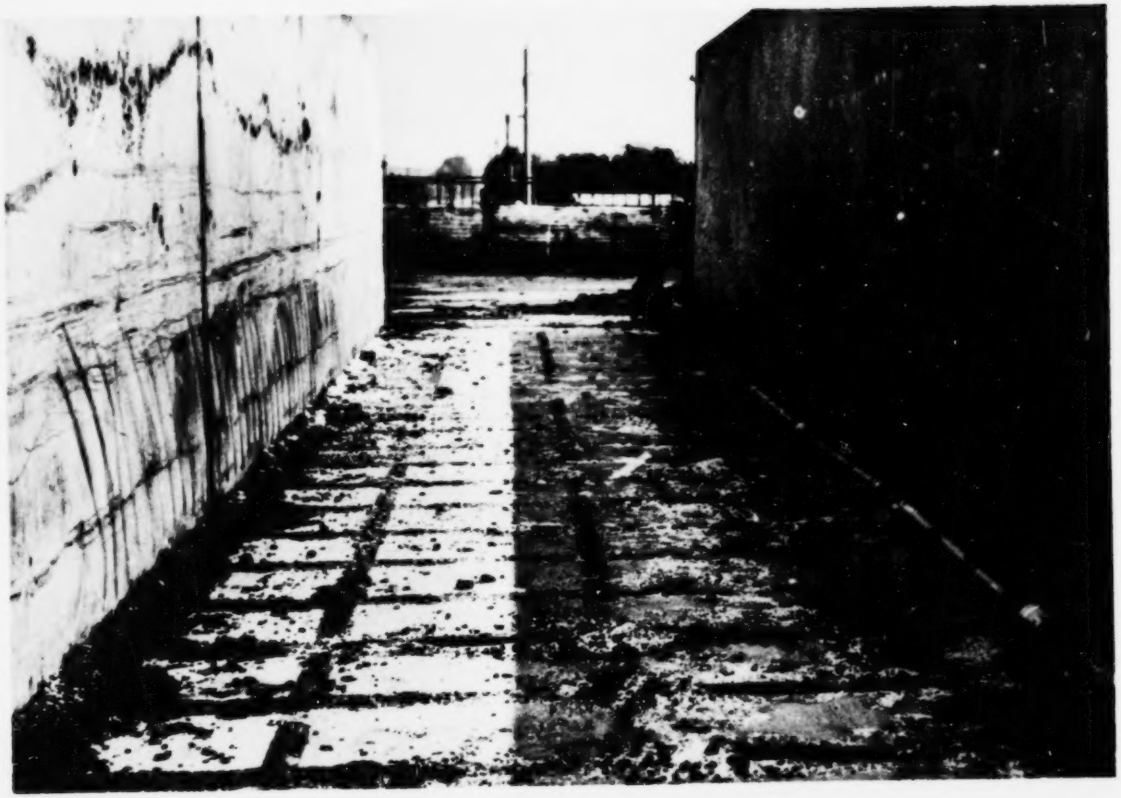

Figure 10. Blower pipes in bin.

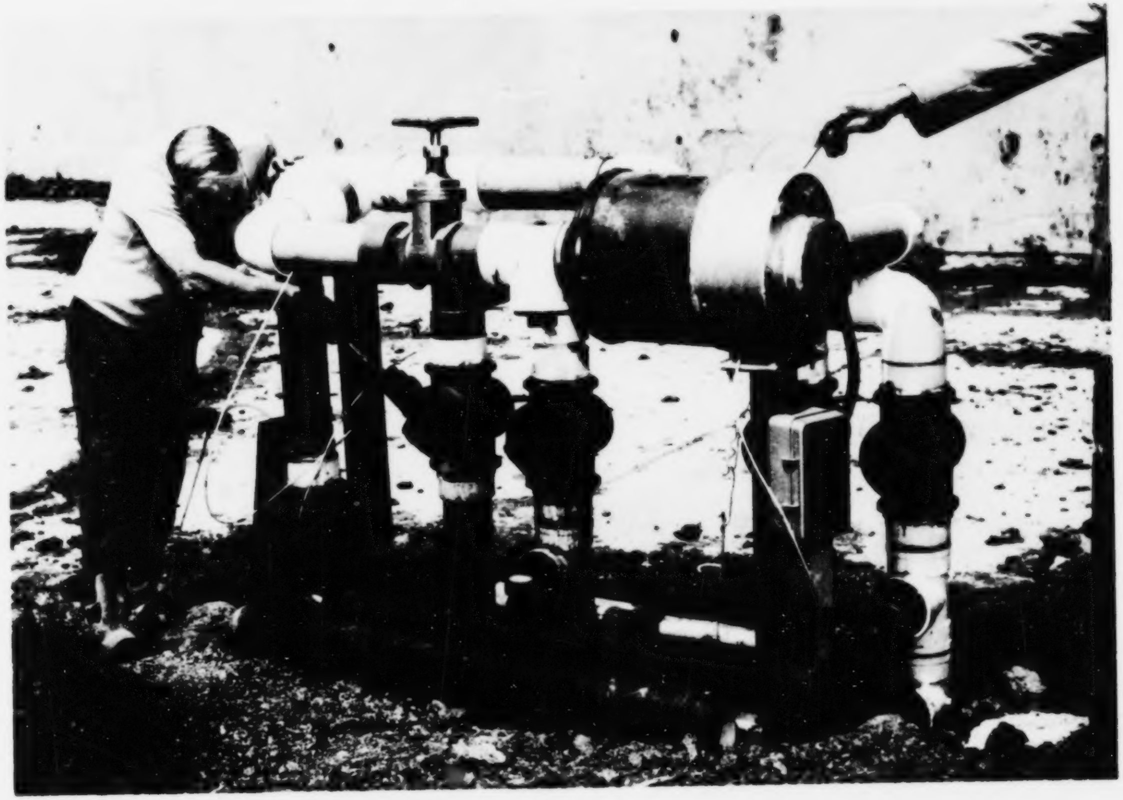

Figure 11. Blower, valves, and gauge system (note timing clock and housing to permit "blowing" or "sucking.")

the bin walls, from all 4-inch grooves, were arranged to provide drainage. However, to prevent escape of air, these had to be plugged with wooden 4- by 4-inch plugs. The air piping system had to be redesigned to permit drainage, and to avoid water accumulations from heavy rains, in the piping (which would stop the flow of the low-pressure air.)

Test Openings. One-inch pipes with threaded caps were installed to penetrate the outer bin walls. These were located two feet, four feet, and six feet above the bin bottoms. There were two vertical rows for each one-third portion of each bin. These were used for measuring temperatures with 3-foot-long stemmed indicating thermometers and for inserting thermocouples connected to a Honeywell (Johnson) recording thermometer; also for occasional sampling with an M.S.A. device to measure the percent oxygen in the gas within the manure compost.

Hauling and Loading Equipment. Manure was hauled to the composting site in Ford dump trucks with double rear axles and a capacity of 10 cubic yards. Loading and mixing was done with Ford Diesel tractors with an open-bottomed scraper bucket behind and a 3/4-cubic yard front-end loading bucket. This equipment is normally used at the dairy for cleaning the earth and concrete corrals and for hauling the manure for disposal on agricultural lands.

The Eagle Loader was used for loading bins, for transferring from the first to the second bin, for unloading the second bin, sometimes for mixing wet and dry manure and compost before loading into the first bin, and to feed compost to the shaker screen.

Sieving and Sacking. A 10-foot by 4-foot shaker screen with nominal 1/2-inch openings was mounted with one end 3 feet 8 inches higher than the other, on a special concrete bin (Figure 12). The screen was fed by the Eagle Loader which, in turn, was fed from piles supplied by the bucket on a tractor. Screen rejects, rock from the corrals, and lumps amounted to less than 15 percent of the volume being screened and was hauled away for disposal. (Crushing or grinding appeared to be uneconomical and undesirable.)

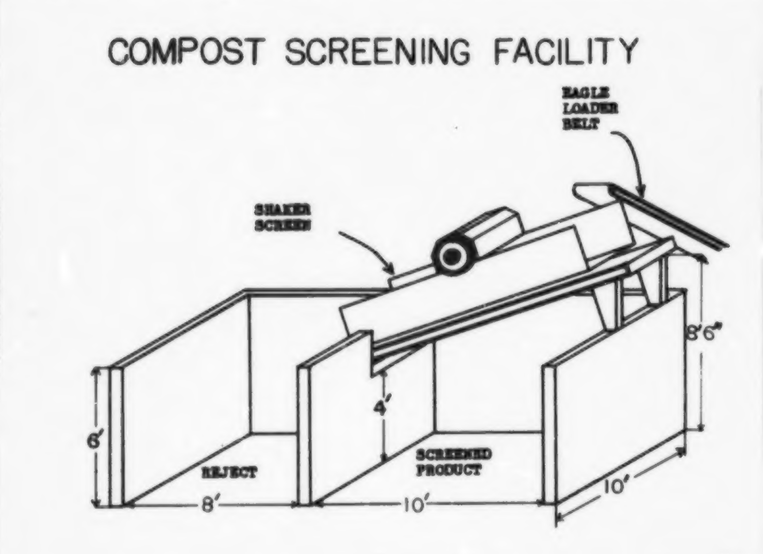

Figure 12. Compost screening facility.

Screened material was loaded into a 10-cubic yard "U"-shaped unit equipped with a corkscrew which moves the material to a dual outlet valve for filling sacks (Figure 13).

Paving. The surfaces surrounding the bins and for stockpiling, sacking, etc., were paved to enable operation in wet weather.

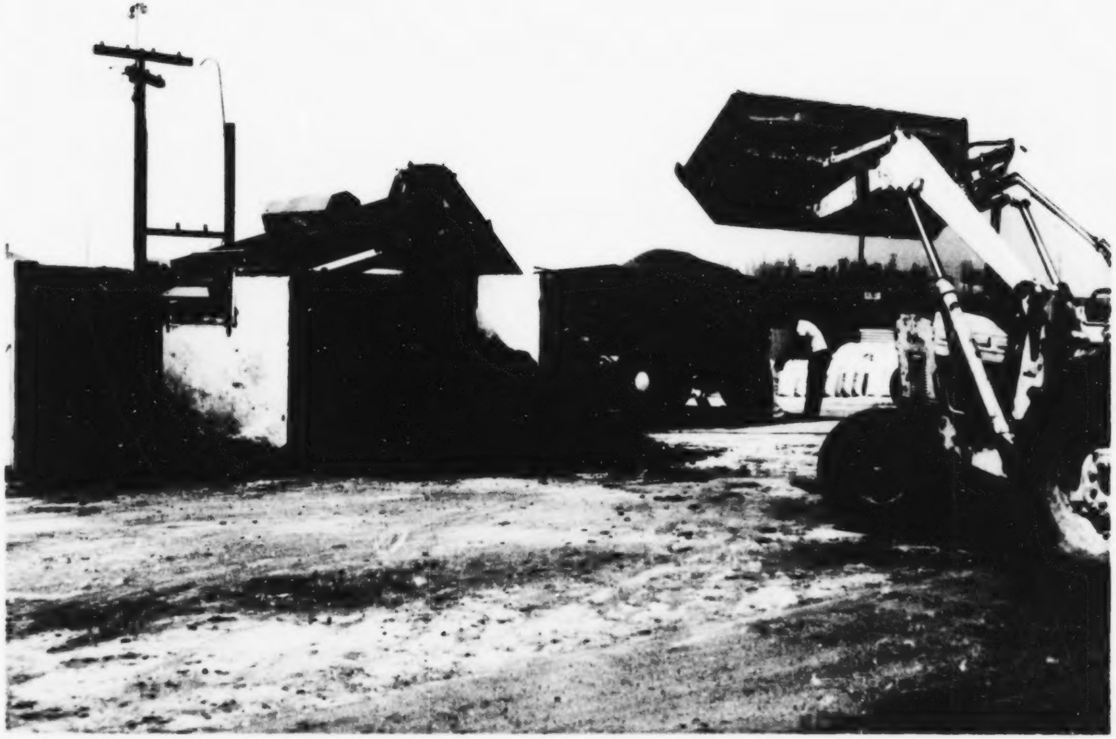

Figure 13. Screen being fed by Eagle Loader.

(Note small proportion of rejects at left and bag filler at right.)

Test Equipment. Moisture determinations were made by either the standard oven and weighing method or on a unit which dries the material in 20 to 30 minutes by an electrically heated coil and which gives a direct reading of percent moisture. The latter checked with the former within 1 to 2 percent, and was used when small numbers of sample were being run, and immediate results were desired, as to check moistures as bins were being loaded (Figure 14).

The most convenient and useful temperature readings were by 3-foot-stem, dial thermometers. For special data on correlation of moisture, airflow, and other conditions such as ambient temperatures, thermocouples connected with a Honeywell recorder were programmed and operated to give readings at 12 different points.

Percent oxygen in the composting mass was measured by an M.S.A. direct reading unit. The probe was arranged to exclude particles and a squeeze-bulb was operated until a constant reading was obtained. The unit was quite satisfactory for several months.

On the other hand, a Beckman unit, connected with a pump, filter, moisture condenser, etc., was not successful. Various probes were built to enable obtaining an adequate inflow. Excessive moisture necessitated improvising a valve to restrict the airflow. However, the unit was not as accurate as the simpler M.S.A. unit.

Bulk Density. A most useful test is bulk density. The weight per cubic foot was obtained with a 1-cubic foot-metal box on a scale set to compensate for the weight of the empty box.

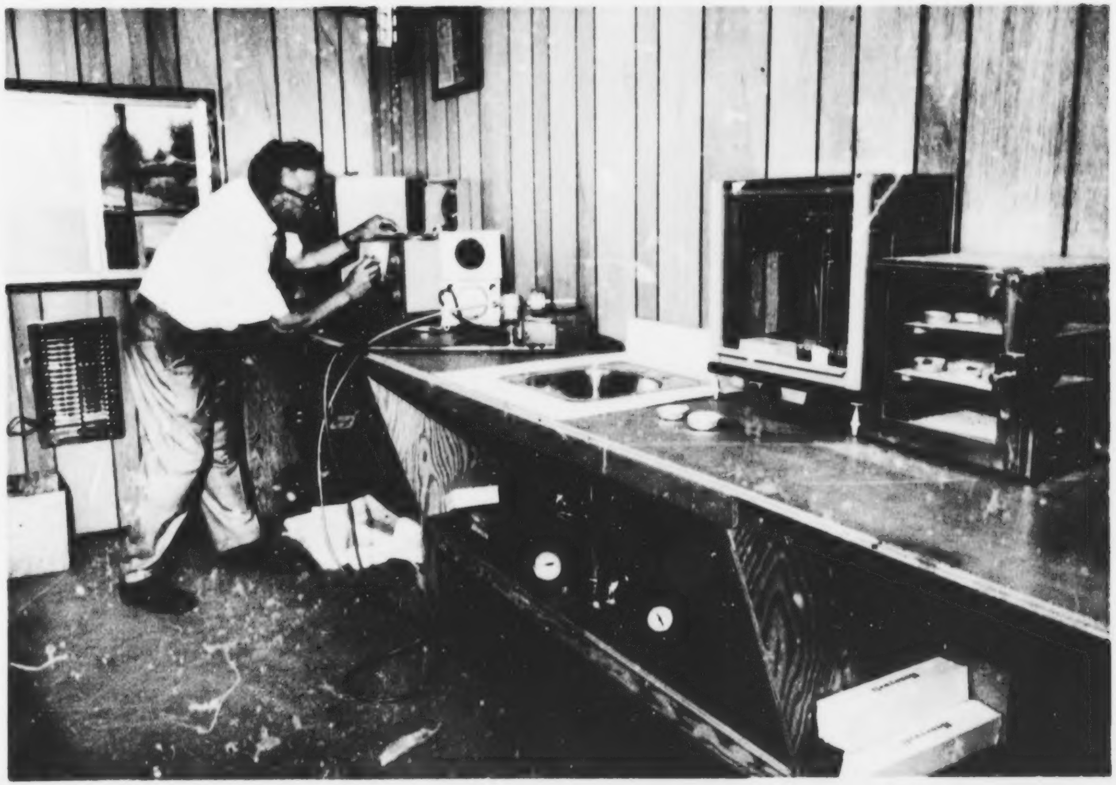

Figure 14. Laboratory at project site--note using direct reading percent moisture unit.

Composition of Composting Material.

Mixing. During dry weather it was possible to adjust the moisture content of the manure by mixing the moist material from paved areas around feed mangers and watering troughs with dry material from the earth surfaces. As will be discussed later, it was found that mixing of 10 percent compost with raw material produced a better soil amendment than by composting raw manure alone. Manure was brought to the slab adjacent to the first bin in 10-cubic yard truck loads. As the 12 truck loads were dumped the 3/4-cubic yard bucket on the tractor was used to scatter compost over the material. The Eagle Loader did a good job of mixing by the action of the corkscrew, bucket-conveyor, and conveyor belt. It was, however, desirable to mix the wet and dry corral scrapings in each truck load to avoid having large, separate masses of wet and dry material.

Moisture Content. As might be expected, too much moisture resulted in packing which prevented proper airflow and made unloading difficult. Without adequate oxygen in the mass (about 6%) the material failed to heat and portions developed a characteristic anaerobic odor and black color. This condition developed with moisture in the 62 to 65 percent range. With wet material, the corkscrew device on the loader would not "dig" into the material so it was necessary to use the front-end loading tractor to loosen and break up the mass. One-inch by three-inch steel plates were welded to the corkscrew to improve efficiency. These were of value. Moisture would ooze from the material and tend to stop the flow of air from the 4-inch slots in the bin bottoms.

It was noted that a simple test would tell the equipment operator when the mix was too wet. When the manure was made into the form of a snowball, and squeezed, if moisture oozed out the mix was too wet.

The effect of high moisture is shown in Figure 15. It will be noted that at 66 percent moisture the temperature rose to 132 F but not higher. Then the bin was unloaded, dry material was added, and the mix was reloade at 61 percent moisture. The temperature then rose rapidly to above 170 F. A parallel test of material loaded at 60 percent moisture reached above 170 F and remained hot for several days. The 170 F was reached in 6 hours, accounting for high temperatures on day '0'.

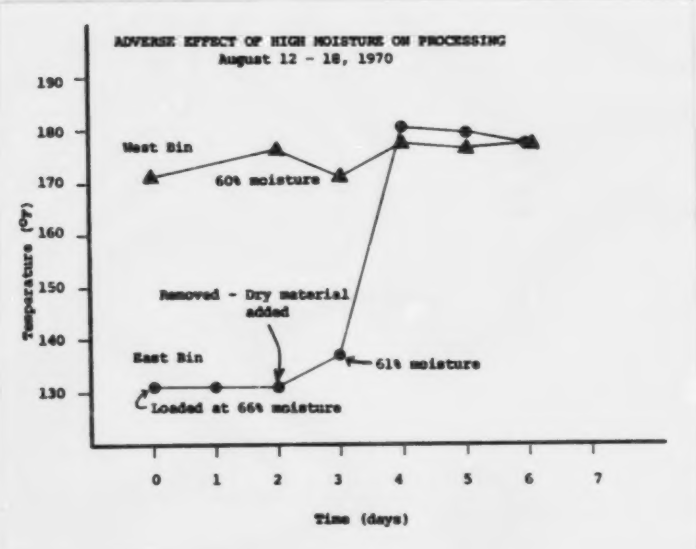

Figure 15. Adverse effect of high moisture on processing.

Figure 16 shows the necessity of breaking up the mass when loading with material of 60 percent moisture content. If the material had been transferred to the second bin at the end of 6 days, it would have been loosened to permit enough airflow to keep temperatures below 174 F--the critical temperature.

The amount of moisture was an important factor concerning the length of time the material would remain hot, during aeration. Normally the thermophilic action would continue as long as the moisture ranged between 40 to 62 percent. The hot airflow through the material tended to extract moisture. When the moisture dropped to below 40 percent, it was necessary to practically stop the cooling effect of the airflow or temperatures would fall to below 140 F.

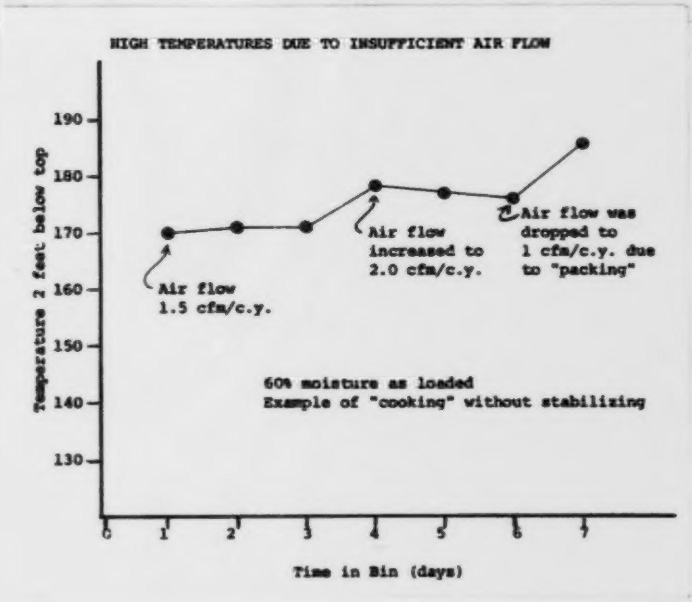

Figure 16. High temperatures due to insufficient airflow.

The effect of low moisture (37% as loaded) is shown in Figure 17. The temperature never reached above 140 F and fell to 100 F in five days with the standard minimum starting airflow of 3 cubic feet per minute per cubic yard.

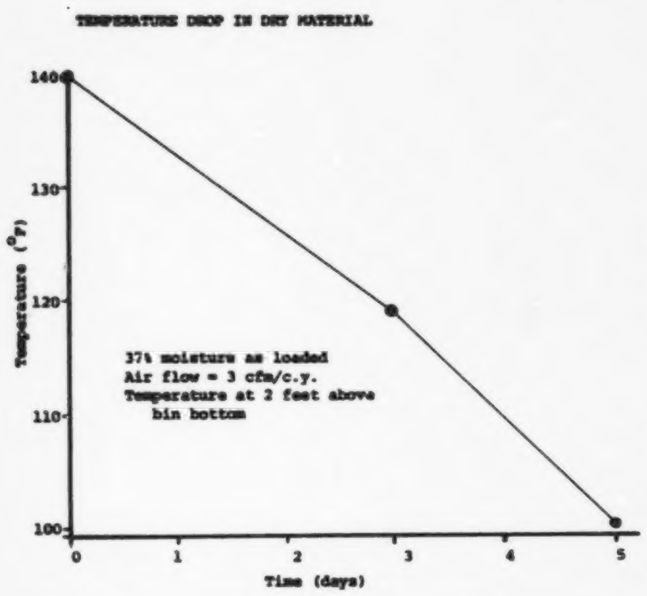

Figure 17. Temperature drop in dry material.

Figure 18 shows that when loaded within 50 percent moisture material, the temperature drop was quite gradual.

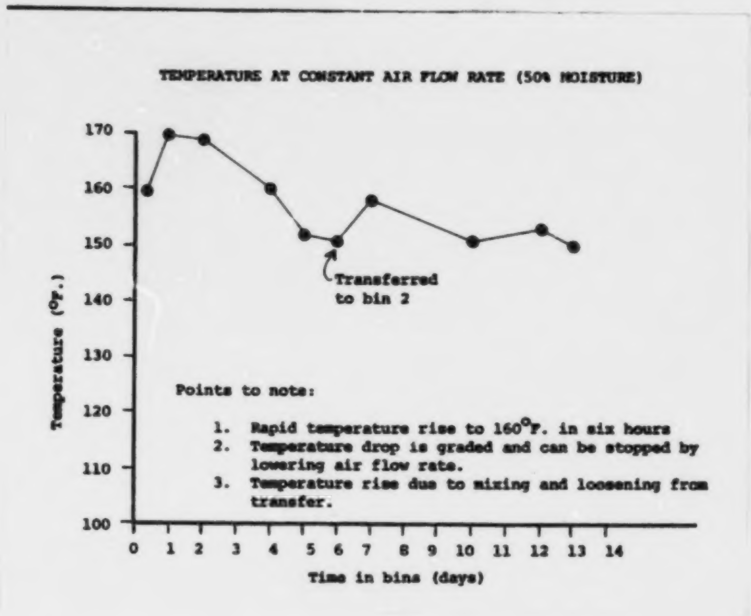

Figure 18. Temperature at constant airflow rate (50% moisture).

Figure 19 shows that with optimum moisture (56%) it is necessary to provide over 2 cubic feet per minute per cubic yard or temperatures reach above 174 F. After the first few days the airflow can be cut to 2 cubic feet per minute per cubic yard and lower.

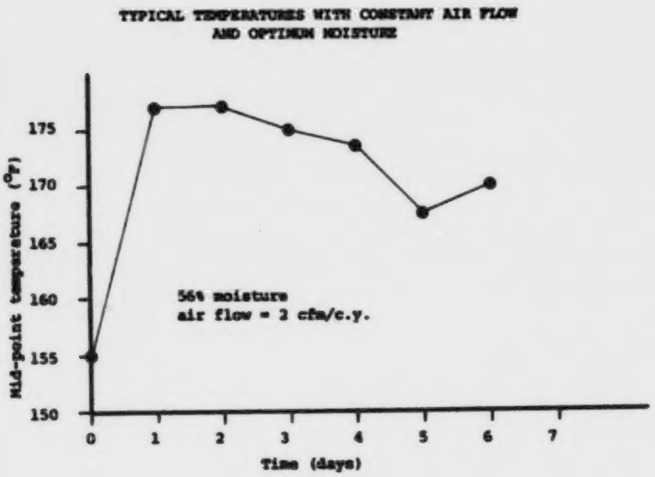

Figure 19. Typical temperatures with constant airflow and optimum moisture.

Figure 20 shows the effect of a lower moisture, the airflow rate being dropped to 1.5 cubic feet per minute per cubic yard.

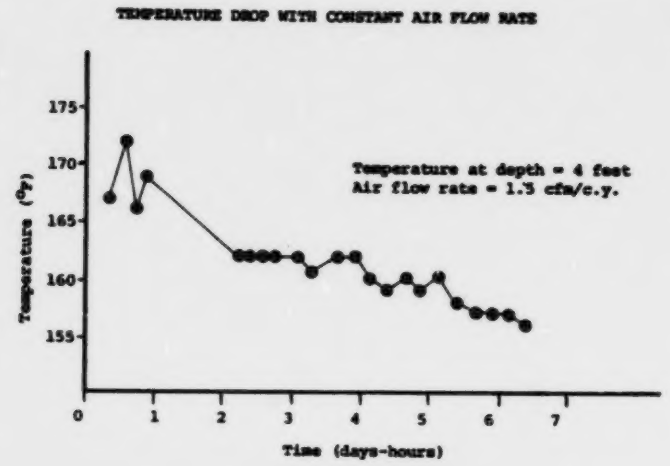

Figure 20. Temperature drop with constant airflow rate.

Figure 21 shows a more rapid temperature drop with 50 percent moisture and 3 cubic feet per minute per cubic yard.

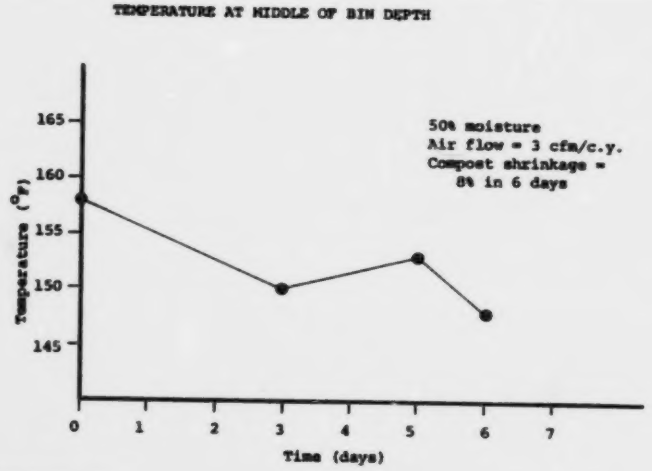

Figure 21. Temperature at middle of bin depth.

Figure 22 shows that high temperatures are maintained with 4 cubic feet per cubic yard through a 60 percent moisture material. Figure 23 shows that with a moist material (58%) and a low airflow rate (1.5 cubic feet per minute per cubic yard) temperatures rose to 190 F. The material was black and had a somewhat "cooked" odor.

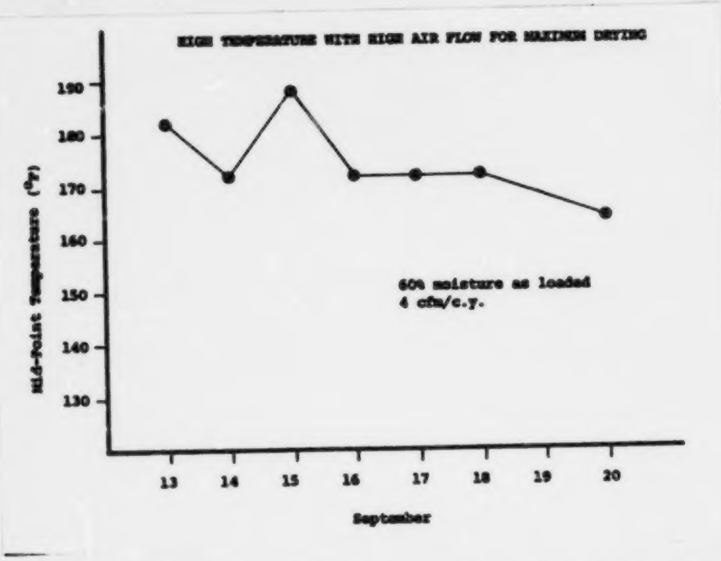

Figure 22. High temperature with high airflow for maximum drying.

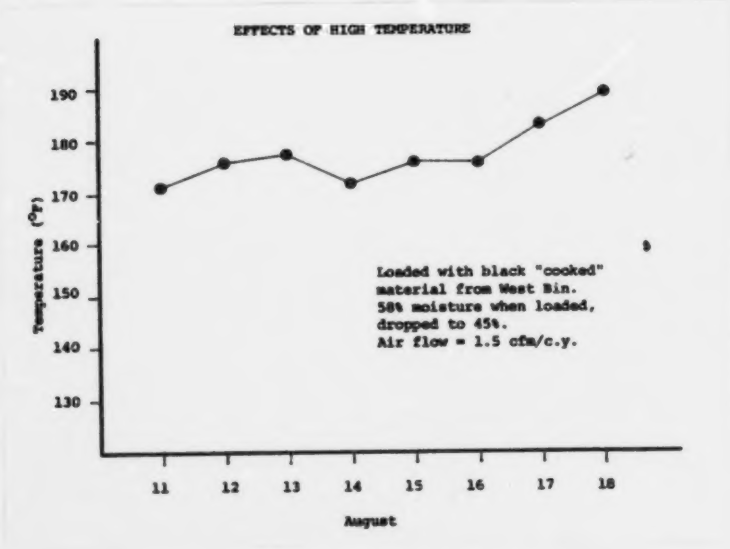

Figure 23. Effects of high temperature.

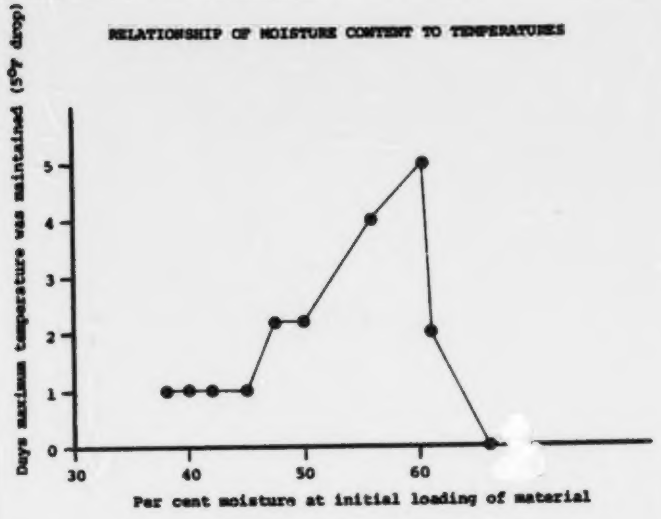

Figure 24. Relationship of moisture content to temperatures.

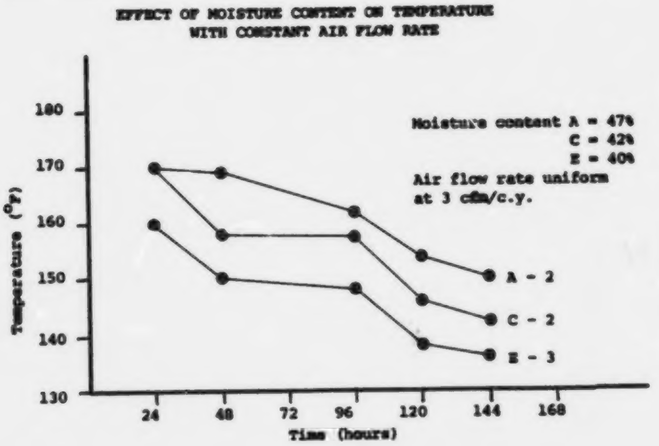

Figure 25. Effect of moisture content on temperature with constant airflow rate.

The data on moisture-temperature relations summarized in Figures 24 and 25 indicate that a moisture content below 50 percent excessively reduces the time when the material is actively being processed; that moisture contents between 50 and 60 percent are optimum. Due to a tendency to pack in the bins at higher moisture content, 55 percent moisture is considered optimum.

Screening. It was found that high moisture content interfered with operation of the shaker screen. When the material had above 34 to 36 percent moisture there was a tendency for the material to plug the screen. Also, when an excessive amount of the material was placed on the screen balls formed. The larger balls were rejected by the screen and smaller balls detracted from the quality of the compost.

Proper regulation to maintain maximum airflow possible at high temperatures aided in drying in the bin to about 35-40 percent moisture. The remaining drying took place during the stockpiling-aging period. As was noted by other investigators, the processed material remained aerobic and kept at above 140 F throughout large piles (9-feet high and 30-feet wide.)

It was realized that the material at the outer edges of the composting mass would not be at suitably high temperatures for pasteurizating and weed-seed inactivation. However, these volumes represented a fairly small portion of the material confined in the bins. Most of this outer material became mixed with hot material at several stages including transferring to the second bin, during transfer and temporary storage outside of the second bin, and during the stockpiling at 140 F. This, it was believed and tests indicated, exposed all seeds and pathogens to adequate temperatures at at least one of the processing steps.

To test this theory, samples of the finished product were "laboratory tested" for weed-seed germination. Also, relatively large quantities were used in flower gardens and on dichondra lawns. In all cases, the material was judged to be weed-seed free. Samples of the material extracted from the bins by semi-aseptic means were free of coliform.

Quality of Product

Since the sum of the amount of nitrogen, phosphate and potassium is considerably below 5 percent the product, unless enriched, cannot be labeled a "fertilizer." However, the soil and plant scientists of the University of California Agricultural Extension Service and at the Riverside Campus do believe the chemical nutrient content is of considerable significance to a number of crops and ground covers, including lawns.

Composted manure normally contains 25 to 30 percent moisture and weighs 25 to 30 pounds per cubic foot. Each 2-cubic foot sack would, therefore, weigh 50 to 60 pounds.

TABLE 2

The following table gives the percent, on a dry basis, of stated constituents of compost from earth corrals and from all-concrete corrals:

Constituent	N	P	K	C	C/N	Salts	Chlorides
Earth	1.4	0.65	2.3	30	25	4.0	0.5
Concrete	2.2	0.78	5.1	--	11	7.5	1.7

Compost from concrete corrals tended to retain nutrients from urine, which largely seeps into the soil of earth corrals. Recycling up to seven times through all-concrete corrals, did not significantly increase the concentration of these chemicals.

The value of compost is probably in its usefulness as a soil conditioner (holds moisture in sandy soil and makes ground more friable in clay type soils) and through slow release of chemical nutrients. For some crops, such as citrus and avocado, the relatively high salt and chloride content is undesirable. Soil and plant authorities collaborating in this project state the salt and chloride content is not deleterious to forrage crops, lawns, and most nursery stock.

While the literature cautions about high nitrate loss as volatile amonia, as C/N ratios get below 30, even with the low C/N ratio of 11 for the recycled material, the loss was found to be in the order of 0.2 percent or less than one-tenth of the total. It was noted that agitation of the hot compost would produce a strong release of ammonia but with normal aeration this odor was normally not perceptible.

Moisture Reduction. By maintaining maximum airflow rate at maximum temperatures it should be possible to produce maximum moisture reduction. At an air temperature of 160 F the air can hold two-tenths of a pound of moisture per pound of dry air. With an airflow rate in each bin of 500 cubic feet per minute, or 40 pounds of air per minute, this should theoretically produce a moisture reduction of 8 pounds per minute or close to 500 pounds per hour. A bin load of 60 percent moisture material weighs approximately 100 tons.

A reduction of moisture of 20 percent would mean a weight reduction of 20 tons. The above calculation would indicate a maximum potential weight reduction of 4 tons per day with an airflow rate of 4 cubic feet per minute per cubic yard and an air temperature of 160 F. This would mean, theoretically, five days of processing in each of the bins to accomplish the desired results. As might be expected, efficiency is materially lower and the moisture reduction was less than one-half of the calculated value. Investigation of this observed phenomenon revealed that the outer 6 inches to 1 foot of the compost was excessively moist, particularly in the mornings. It was also noted that the outer layer of compost was at near ambient temperature. As the wet, moisture laden air passed through this layer it was significantly cooled and lost some of its moisture. This led to serious consideration of utilizing the German practice of aeration by suction rather than blowing. This would have the effect of removing the hot moisture laden gases without the moisture-condensing effect of the surface layer of the compost pile. This process will be discussed later.

Conclusions From Processing of the Manure From Earth Corrals

The material can be successfully processed if loaded at moisture contents ranging from 45 to 60 percent. Optimum moisture content is in the range of 50 to 55 percent. This is significantly over the maximum allowable moisture content for processing by aging in stockpiles as was practiced at the Dairymen's Fertilizer Cooperative where the moisture range had to be kept down to 35 to 40 percent. It is therefore apparent that the process can utilize material significantly more moist than is acceptable for the stockpiling method. In addition, as is mentioned elsewhere in this report, it was found that adding compost tended to produce a more desirable product. This added compost also acted as a drying agent. It was therefore possible to remove manure from corrals four or five days after a rain, mix it with some compost, load it in bins, and successfully compost. The literature indicates that manure and other organic material contain enough organisms of the right type and of the right quantity for effective composting. Preliminary observations of the project, on the other hand, indicate a better quality product resulted when a 10 percent compost was mixed with the raw manure. To further test this theory parallel bin operations were conducted. In one bin raw manure from earth corrals was loaded without adding any compost. In the other the same type corral manure but with a slightly higher moisture content was mixed with compost. The two bins then were processed with material of approximately the same moisture content, the same airflow rate, and other characteristics. The only difference was that one contained 10 percent compost and one did not. During two weeks of composting it was found that temperatures of both bins rose to and remained at approximately the same levels. Therefore it appeared that processing was equally good in both. However, after two weeks the material to which no compost had been added remained a sort of a yellow color and its texture was close to that of unprocessed, dry cow manure. The other material had developed a more brownish color. When moisture was added to both it was found that the material to which no compost had been added tended to attract and breed flies. The other did not. These tests were repeated. While the results are not necessarily conclusive they do appear to confirm the observation in the bench-scale tests, that the addition of compost seems to provide the bacterial seed of the stabilizing type organism that are requisite for producing an optimum product.

Preparing Compost for Market. It was found desirable to stockpile the compost for two weeks to a month. It was also found that if at the mid-point of composting the material was run through the Eagle Loader this resulted in a considerable amount of moisture reduction and assisted in maintaining relatively high temperatures in the stockpile over the entire storage period.

There was a question on whether or not the material should be run through some form of shredding device. It was decided that the initial processing would simply be running the material through a shaker screen. At first the screen was loaded by attempting to shake material from the bucket of the front-end loader on a tractor. However, this resulted in too much of the 30 percent moisture material piling on the screen at one time and caused plugging of the screen's openings. The Eagle Loader was then used for loading, and by regulating its speed it was possible to keep the screen loaded with just the amount that would be effectively screened in its travel down the screen.

It was found that the rejects constituted somewhere between 5 and 15 percent of the total volume. A considerable part of this was stones and rocks from the earth corrals. In view of this small volume, it was determined that it was not economical to develop and utilize a crushing device.

Alta-Dena Dairy built a portable bin and sacking device. This is a 10-foot-long, 4-foot-wide "V" bottomed tank type body. At the bottom, along the "V" is a corkscrew which moves the material toward the sacking end. Slots above the corkscrew can be opened or closed to adjust the rate at which the material drops to the corkscrew and its housing. A dual outlet valve enables filling one bag while placing another to be ready for filling (see Figure 26). The material was placed in plastic bags which were originally sealed by a heat

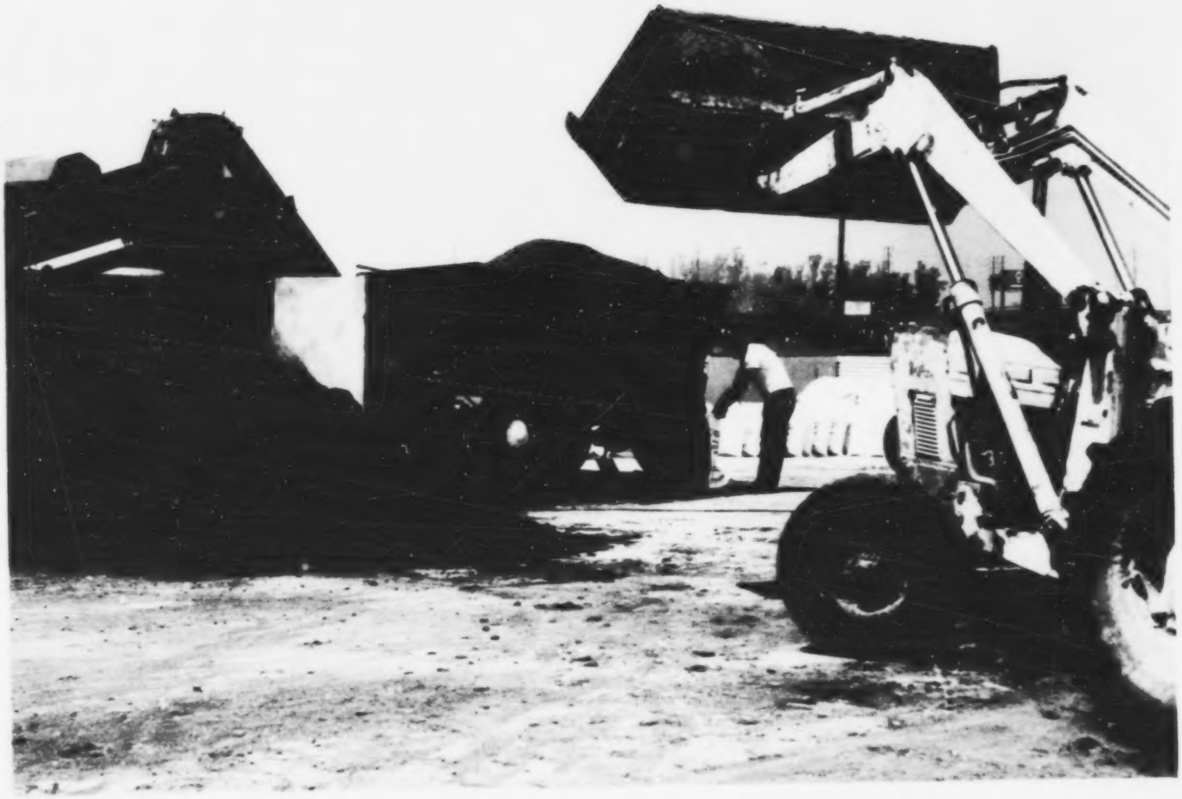

Figure 26. Compost storage bin and sack loader.

device. Later it was decided sewing produced a more reliable sack closure. Whereas the German scientists have advocated that the bags be porus to "permit the material to breathe" the Alta-Dena product was practically hermetically sealed and remained attractive and relatively odorless, and there was no indication that a hermetically sealing type bag was not perfectly satisfactory.

Conclusions From Phase One of Demonstration Project

It can be concluded that the method demonstrated produces a desirable compost which sells at retail for $.89 per sack and wholesale for more than $.50 per sack, while the total cost of production is about $.33 per sack (see Chapter 6). The product is highly acceptable to amateur and professional gardeners and garden supply dealers. The process has the following advantages:

1. It can be conducted at each dairy, thereby avoiding problems resulting from centralized hauling and processing operations.

2. It can successfully process wet material in wet weather, thereby obviating a major problem of managing manure in wet weather.

3. The method is relatively simple and appears to require considerably less manpower and equipment time than windrowing or other methods.

4. The operation is odorless as indicated by the fact the project is located within a few hundred feet of a dense housing development. No complaint was ever received about odor. The observations of project operators and consultants also confirmed the odorless nature of the operation.

5. The product was demonstrated to be weed-seed free in several ways:

(a) Tomato seeds which are judged to be more resistant to heat and other destructive effects than weed seeds, were inactivated when placed in perforated containers filled with manure, placed in various locations within the compost pile.

(b) Samples were tested by the Soil and Plant Laboratory and the University of California at Riverside. Also, project participants mixed compost with soil which was kept moistened and otherwise maintained in a way to germinate seeds. The project participants also used the material on lawns and gardens and noted no weed development. All tests demonstrated the product to be "weed-seed free."

6. The material was considered to be pathogen-free because repeated samples were found to be free of coliform. Experts, including the Chief of the State Viral and Rickettsial Laboratory, reviewed the temperature data and indicated that the temperatures obtained would inactivate the more resistant organisms such as the causitive rickettsia organism of "Q" fever. Entomology team tests consisted of placing the product in containers and moistening it to the optimum degree for fly larvae development. These containers were then placed next to material known to be attractive for development of fly larvae, and fertilized female flies were released. The processed material did not attract flies, nor did any fly larvae develop in that material, whereas the other moist material produced flies.

Disadvantages of Method. One of the more serious disadvantages of the method was the problem of loading and unloading with a machine that would periodically break down or would fail to function effectively when the material was slightly more moist than optimal. Loading and unloading of bins with the tractor and skiploader was time consuming.

Higher than average moisture concentrations were noted on the surface of the material, as described above, and material next to the walls was normally wet and packed, due to condensation of moisture by the relatively cool temperatures of the concrete walls.

It was difficult to prevent the pipe system from becoming flooded during heavy rains.

Modifications Indicated by Study. The problems attributable to use of bins lead to considering processing in open piles, as discussed in the following chapter.

CHAPTER 3

COMPOSTING WITHOUT BINS AND AERATION BY "SUCTION"

The first phase of the project utilized relatively few yards of material in each batch. Airflow rates were found to be critical. It was especially noted that relatively high rates produced excessive cooling, and rates which were too low, especially with a moist batch, also resulted in low temperatures at depths more than 18 inches beneath the surface. Airflows were too high at edges of open piles and too low at the center. On the other hand, when the material was confined in bins it was possible to achieve uniform airflow. This lead to the conclusion that the process should be carried out in bins.

As originally planned, the management of manure from a considerable number of dairies in a region would be conducted under the technical and managerial guidance of a cooperative organization, similar to the Dairymen's Fertilizer Cooperative. However, in place of a central stockpiling, storage, and sacking operation, the cooperative would:

1. provide technical guidance
2. perform sacking and marketing
3. obtain and use special equipment which would be moved from dairy to dairy.

The Eagle Loader, for instance or similar equipment, it was planned, would be moved from dairy to dairy to load and unload bins. Sieving and sacking equipment would be similarly mobile. As the project proceeded, it became apparent that the method would be more desirable if the composting could be accomplished with tractors normally used for cleaning corrals, and available at all dairies.

The possible advantages of processing over pipes in open slabs were so significant that Alta-Dena Dairy management built such a unit. Three pipes were laid 6 feet apart and in two sections, each 30 feet long. Each section would process 140 cubic yards of manure. The unit demonstrated that temperatures and other indications of processing were at least equal to those in the bins. Units could easily be loaded and unloaded with the tractor's skiploader. Processing over slabs would materially reduce the cost of construction and obviate the necessity of utilizing special equipment for loading and unloading. In other words, the whole operation could be carried out with equipment normally available at this type of a farm or dairy operation. The suggested design is shown in Figures 27 and 28. The two 30-foot-long parts of the aeration system were separately valved to allow use of either of the units and to permit different airflow rates in each. The blowers which had been originally installed were also connected to the systems.

Manure, with some compost, was piled over the pipes to a maximum height of 9 feet, which was the limit of the height of the bucket. The base of the pile was 18 feet to 20 feet wide, the material extending about 3 to 5 feet beyond the sides and ends of the aeration pipe lines. The pile was an average of 65 feet long, 15 feet wide, and 7 feet high, or a volume of close to 280 cubic yards. This is equal to the capacity of the two bins.

The temperatures could be maintained above 160 F throughout most of the pile. Loading and unloading was done with a front-end loader on the tractor normally used for cleaning corrals. The overall efficiency was higher than with the bin operation.

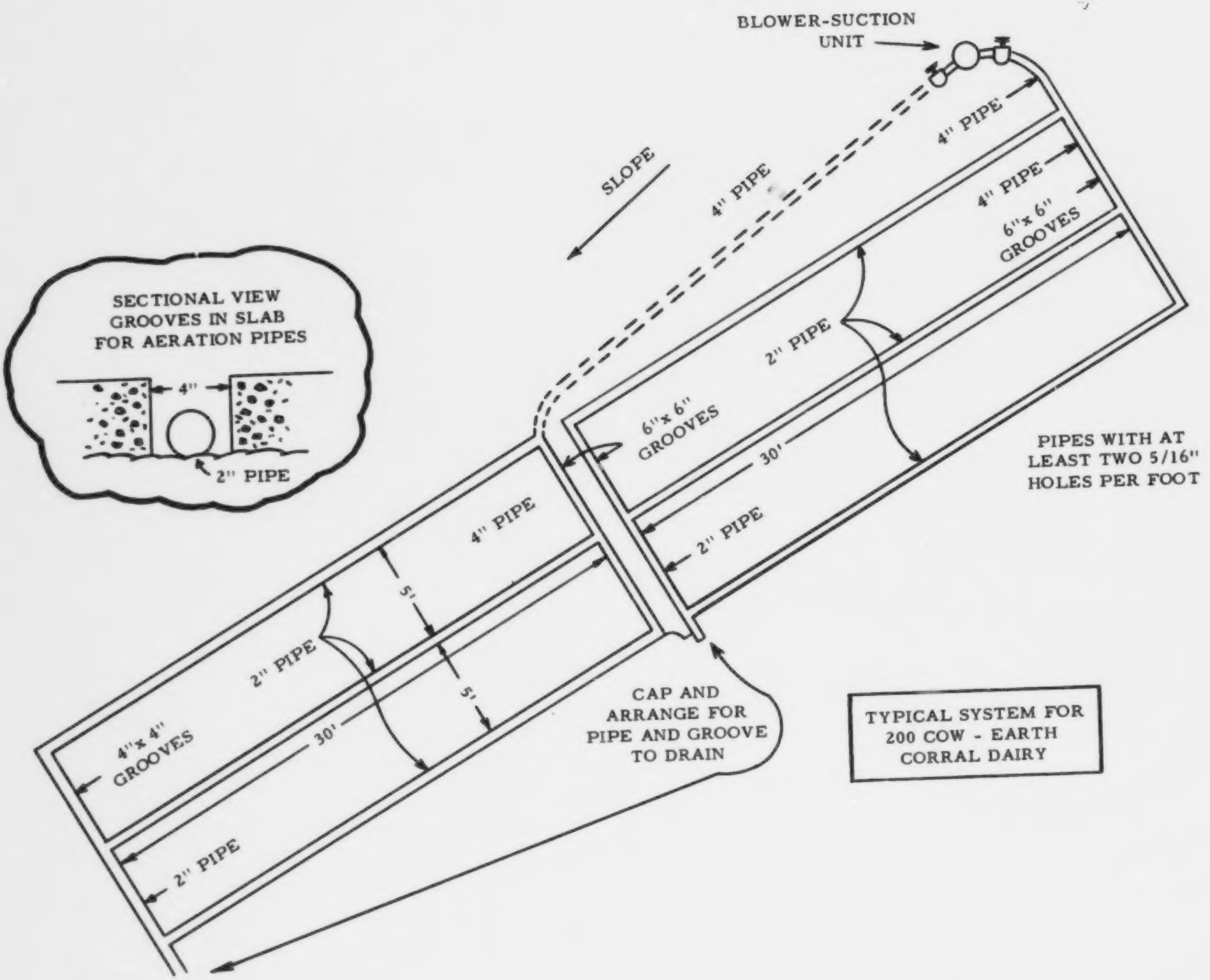
BLOWER-SUCTION UNIT
SLOPE
4" PIPE
4" PIPE
4" PIPE
4" PIPE
6"x 6" GROOVES
SECTIONAL VIEW GROOVES IN SLAB FOR AERATION PIPES
4"
2" PIPE
2" PIPE
6"x 6" GROOVES
30'
PIPES WITH AT LEAST TWO 5/16" HOLES PER FOOT
2" PIPE
2" PIPE
4" PIPE
5'
5'
2" PIPE
CAP AND ARRANGE FOR PIPE AND GROOVE TO DRAIN
TYPICAL SYSTEM FOR 200 COW - EARTH CORRAL DAIRY
4"x 4" GROOVES
30'
2" PIPE

Figure 27. Typical system for 200 cow earth corral dairy.

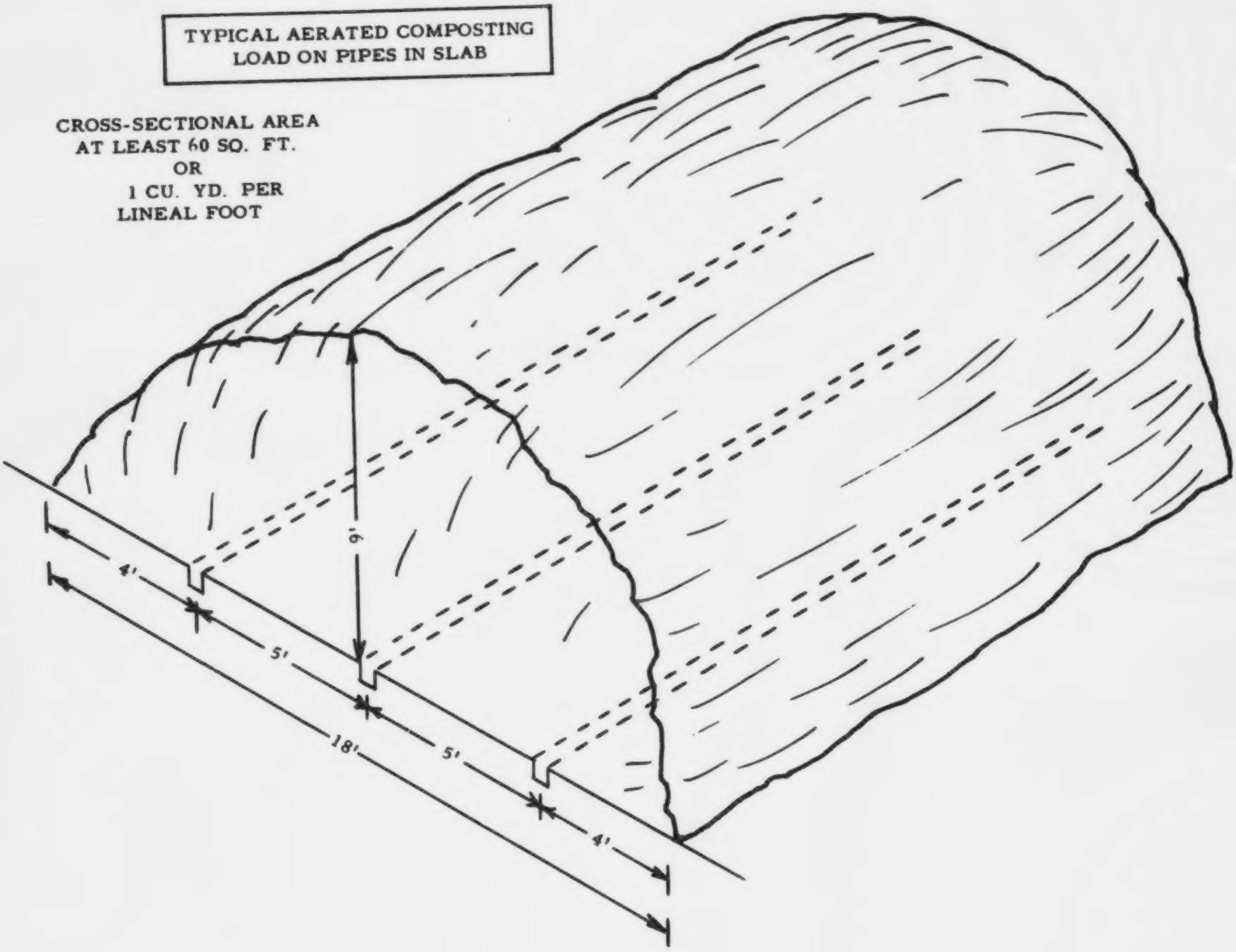

Figure 28. Typical aerated composting load on pipes in slab.

Aeration by Suction

German composting scientists who visited the project contended there are advantages to composting by "suction." They said there is merit in drawing the cool ambient air through the top surface because blowing creates excessively cool zones around the aeration pipes. This lead to a theory of the Project Director that the system should be designed for alternately blowing and sucking. He therefore designed a special housing so the blower could be used as a suction device. Valves, gauges, and other apparatuses were devised and modified to enable this type of operation (Figure 29).

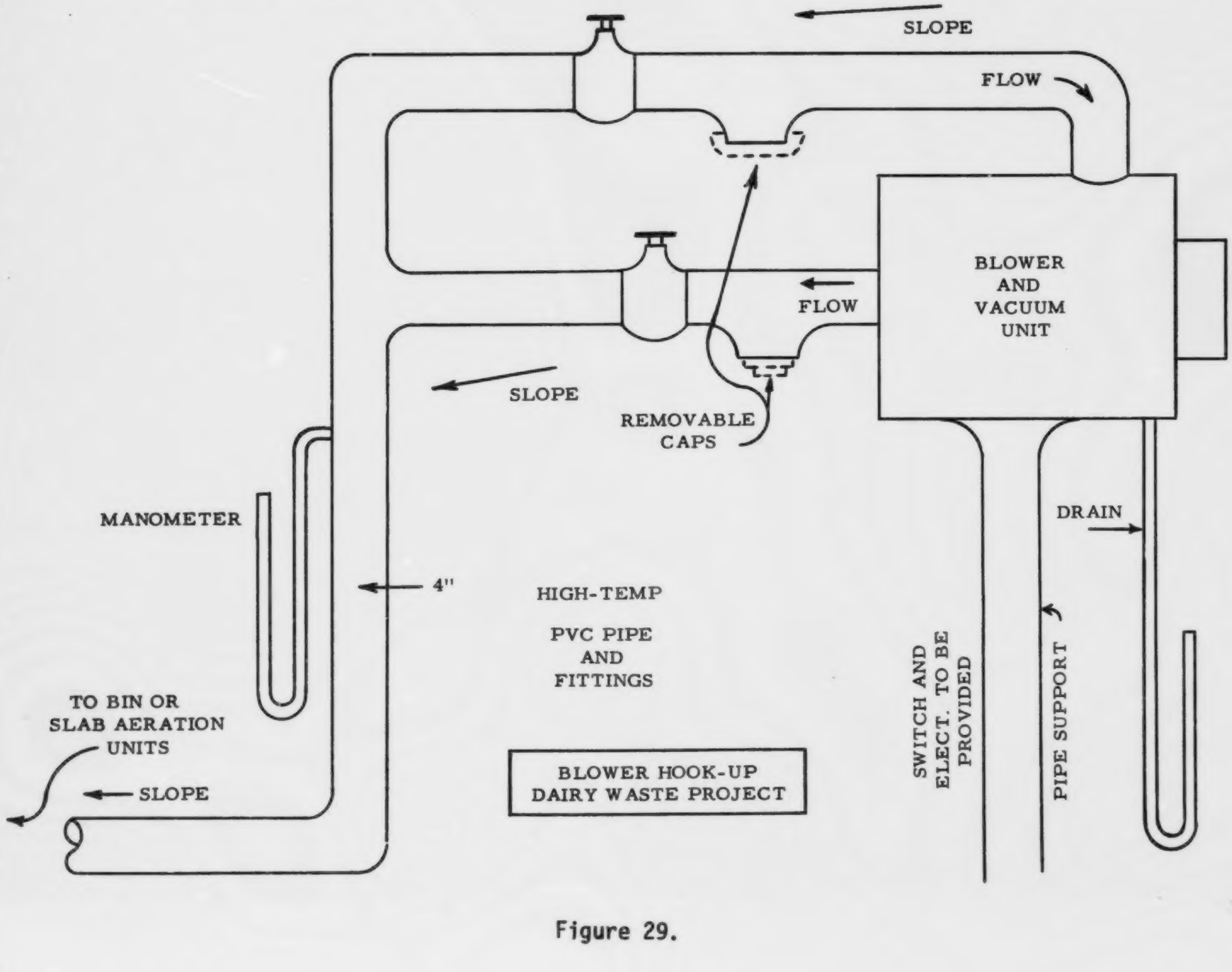

Figure 29.

Suction was then applied to the material being processed over pipes in the open slab. These had been laid on a slope so that moisture accumulations in the pipe would run out of the end. It was necessary to install moisture drainage traps on the pipeline system leading to the blower and on the blower itself. It was noted that the hot moisture laden air would cool sufficiently in passing through the pipes to produce relatively large amounts of condensate. By avoiding surface condensation, suction did result in a slightly better rate of moisture removal, not as great as had been anticipated. It had the advantage of drawing the hot gases down to heat the material around the aeration pipes. This contrasted to the relatively cool zone around those pipes when processing by forced aeration. Contrary to expectations the air entering the pile did not cool the surface and temperatures of up to 150 F or 160 F were found within 3 or 4 inches of the surface. (Figure 30).

When the pile was covered during rainy or in threatening weather and the system was operating as a blower it was noted that the confined hot air and steam tended to heat the entire outer surface of the pile. One experimental operation consisted of blowing for one day without a cover, to raise the temperature, then covering for two days to confine the hot air and hot steam to warm the outer surface. The pile was then covered and the unit was changed to aerobically process by suction. This processing, coupled with the heat processing that naturally occurs during the aging period, resulted in a weed-seed free, properly processed product without any work of turning. This would appear to be optimum method of processing manure from earth corrals.

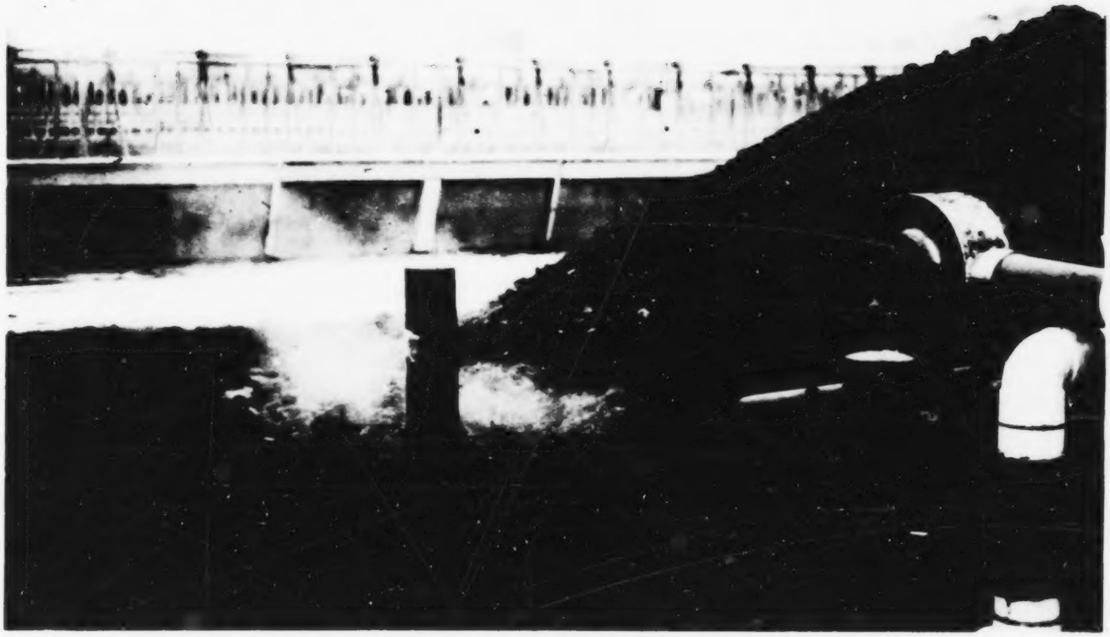

Figure 30. "Sucking" air through pile on slab, discharging moisture to atmosphere.

CHAPTER 4

WATER POLLUTION PROBLEMS ASSOCIATED WITH DAIRY WASTE MANAGEMENT

Surface Water Pollution From Earth Corrals

During the course of the project, the California State Legislature, as did many other State legislatures, passed new pollution control laws which provided agricultural waste are subject to the same type of pollution control regulations as are municipal and industrial wastes. Discussion with Water Quality Control officials and others revealed that standard earth corral dairies which are sloped to drain to water courses, either directly or indirectly, would produce pollution of surface waters in violation of State laws and regulations. In other words, a dairy that is properly graded to enable maintenance without fly and odor production in the spring would normally be a natural source of pollution (Figure 31). Observations at a nearby water flush all-concrete dairy revealed extreme difficulty with disposing of liquid waste; some would excessivley pond in the field, a portion would overflow into roadside gutters and ditches. These observations confirmed recommendations of the project consultants, namely that effort be made to develop a method which will confine manure and urine on concrete from which it can be removed mechanically, rather than by being mixed with large quantities of water.

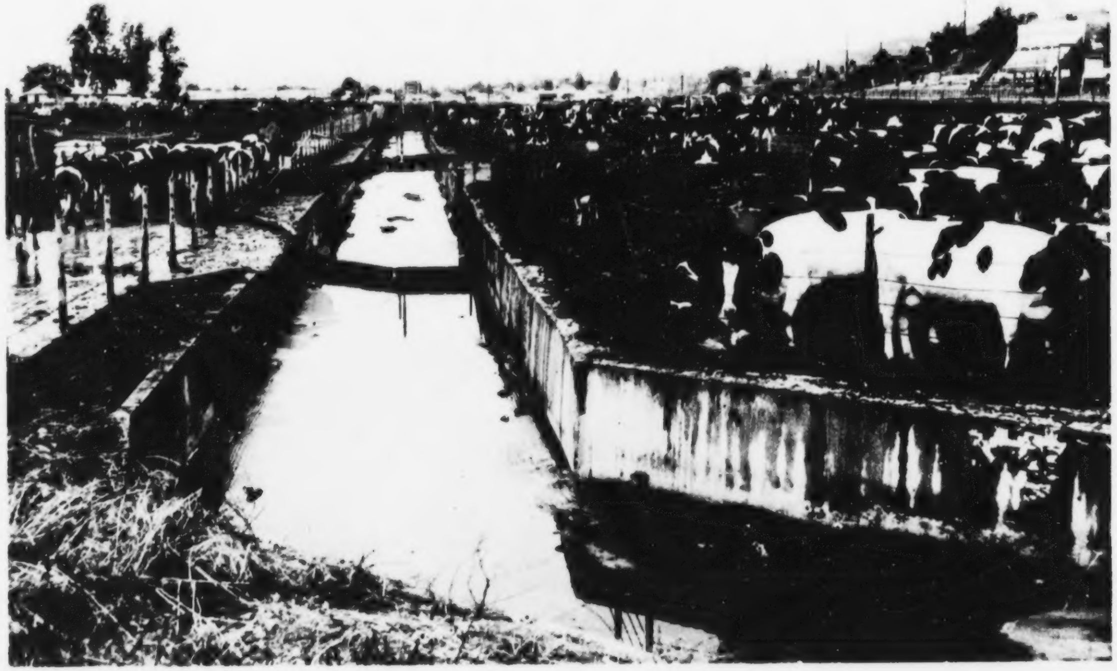

Figure 31. Good drainage from earth corrals creates potential surface water pollution.

Underground Water Pollution

Another motivating factor for modifying project objectives was tests conducted by Professor Pratt and his colleagues at the University of California at Chino. Their tests were made in the Chino-Corona basin. The investigators installed a series of Lysomoter wells in earth corrals and on farm lands receiving solid and liquid wastes from dairies. Their tests confirmed what might be expected, namely, that phosphates remain in the upper few feet of the soil but that nitrates, like many of the other salts, travels through extensive depths of soil to reach the aquifers. Their observations and calculations indicate that nitrate concentrations in the aquifer will exceed the 10 milligrams of N per liter permitted by the Public Health Service standard, unless cow copulations are kept in the order of four or less per acre. This, of course, would be economically infeasible for dairies in areas where land costs are from three to twenty-thousand dollars per acre as they are at many of the southern California dairies.

Already the dairy industry is finding it difficult to economically meet standards such as those of San Bernardino County limiting cow density to 20 cows per gross acre. These factors led to an extensive series of tests and preliminary demonstrations at the project to perfect methods of raising cows in covered housing and without causing surface or ground water pollution from the feeding and housing facilities.

Pending Enforcement Action

The Santa Ana Regional Water Quality Control Board, after conducting studies and analyzing data, is beginning an enforcement program aimed at reducing surface and underground pollution from dairies. Of major concern is the above-mentioned Chino-Corona basin, 40 miles east of Los Angeles, with its 115,000 cows. The Regional Board is asking dairymen in its jurisdiction to detail how they propose to avoid pollution by surface drainage from their dairies. Of equal concern is the realization that nitrates are percolating into the upper aquifer at a rate to materially exceed allowable limits for drinking water. The present cow population is nine per gross acre. Calculations were made to take into account the amount of nitrates taken up by plants, lost by de-nitrification within the soil, loss by surface run-off, etc., and dilution by rainfall and imported irrigation water. The conclusion is that with present waste management practices, there should be a limit of three or four cows per acre.

The major sources of this form of pollution are:

1. use of large amounts of manure and manure-urine containing waste water on land of limited area,
2. direct downward percolation from earth corrals.

One possible solution would be to construct a special or community sewerage system to collect liquid dairy waste. This would enable use of water-flushing methods in roofed, all-concrete floored cow housing, and provide an outlet for drainage from milking parlors. The high nitrate, phosphate, chloride, and other total dissolved solids would necessitate either: (1) an outfall sewer to the ocean; (2) test tertiary treatment, plus special solids management for the close to 900 tons of dry solids produced per day by 115,000 cows.

Another possible solution was investigated during this project, as discussed in the next chapter.

CHAPTER 5

MANAGEMENT OF COWS ON ALL-CONCRETE SURFACES

As mentioned earlier, project studies showed that water-flushed, all-concrete floored cow housing, with suitable "free-stalls" in which the cows rest and sleep, do provide a method of managing waste with a minimum of labor (Figure 32). A comparison of the fly production aspects of this system, as compared with earth corral systems, is detailed in Appendix 2. It is concluded that this system is suitable when:

1. there is a sewerage system to satisfactorily collect, treat, and dispose of the waste, or
2. where there are adequate areas of land on which the liquid can be spread for irrigation and where it can be disposed of without creating pollution problems.

It appears that where such conditions do not exist and high-density cow housing will be located on limited land areas, alternative methods must be considered and one is the "dry" method. With this objective, the project included a six month demonstration in one of the four 90 cow, all-concrete, free-stall facilities at the Alta-Dena Dairy. These units are 185 feet long and each has two 15-foot-wide areas extending the length of the units. Tandem, head-in, free-stalls house 45 cows on each side. These were covered but the "loafing" and feeding areas were not covered. These facilities could be used only during the eight or nine months of dry weather but not during the rainy season, because of the impossibility of managing the very wet manure.

It was observed that the cows would tend to lie on the open concrete areas, in place of their stalls. It was further noted that the cows' feet

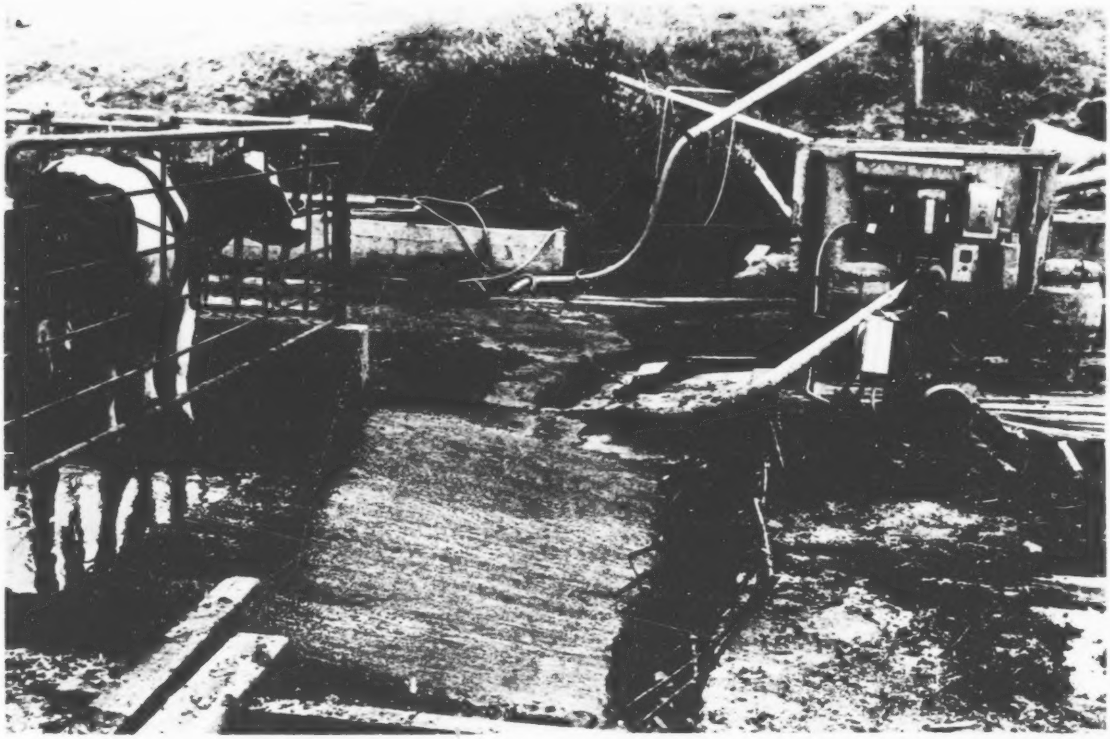

Figure 32. Water-flushed dairy drain.

seemed to be free of soreness, common in the wet concrete facilities, and there was no fly breeding or odor problem from the system. (Figure 33).

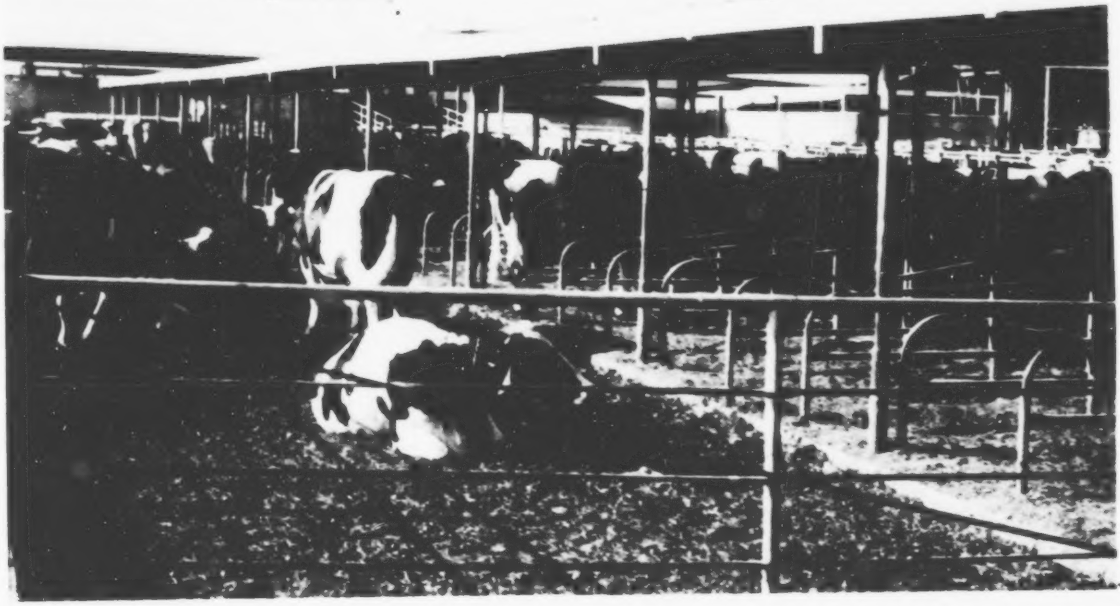

Figure 33. Cows prefer compost on slabs to their free-stalls.

As was expected, this phase of the project was interrupted by heavy rain in late November. However, the experience did lead to the conclusion that the recycling system should be studied in more depth and in completely roofed facilities, through a rainy season.

It was decided that two roofed units should be built, to house 100 cows each. The cows slept on compost on the floor in preference to using their free-stalls, therefore, these new units were designed to be "loose housing" (Figure 34), "pole barns" with roofs high enough to not interfere with operation of dump trucks and loading equipment, and to facilitate ventilation, aeration, and admittance of sunlight. Elimination of the free-stalls avoided the excessive amount of hand labor necessary to keep free-stalls clean and covered with bedding. The facilities were built, financed and subsequently operated by Alta-Dena Dairy.

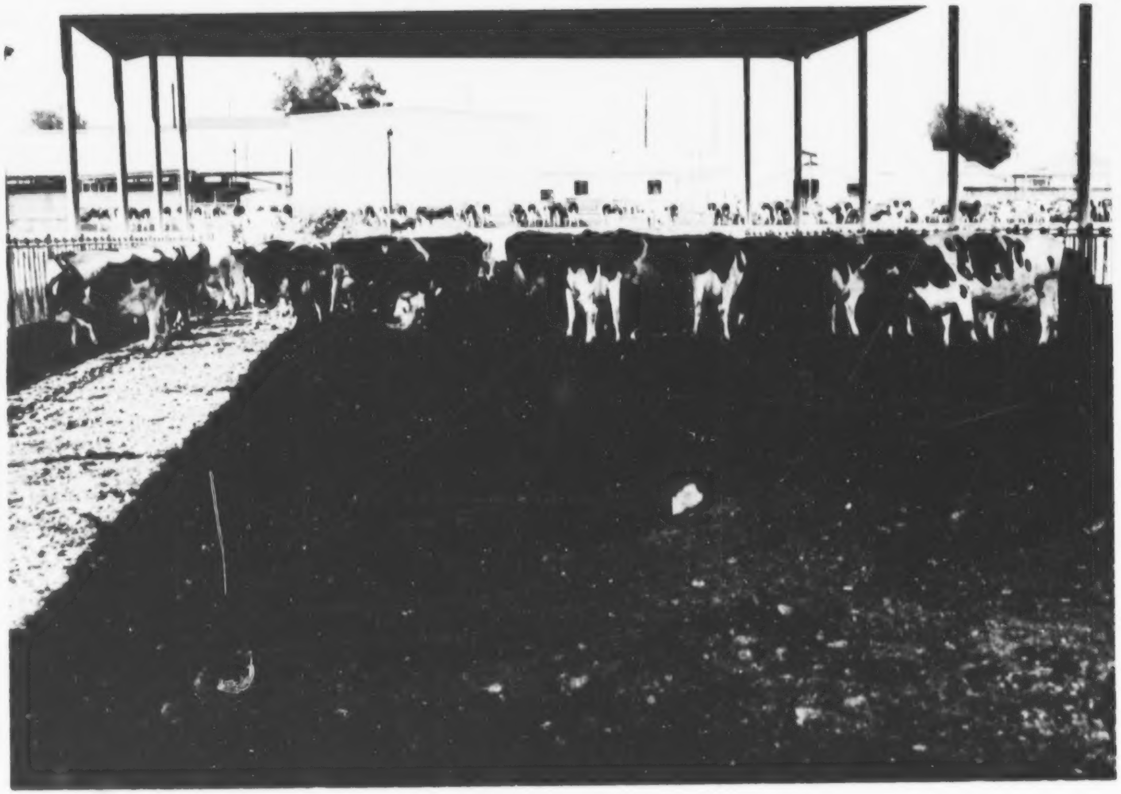

Figure 34. 100 Cows on compost in roofed "loose-housing" facility.

In normal, dry-weather operation, the concrete loafing and feeding areas were cleaned twice a week. The existing system involved dragging a bottomless bucket behind a rubber-tired tractor to drag the wet (88% moisture) manure-urine mixture to a nearby earth corral. Here it was spread in 4- to 12-inch lagers for some drying. However, within three or four days the material was heavily infested with fly larvae and so, while still very wet, had to be hauled by dump truck for application to agricultural land. Various methods, such as harrowing, failed to dry the material. Efforts were made to mix dry compost with the wet material but this was nearly impossible with the available equipment such as tractors with front-end loaders, harrows, and the Eagle Loader. Some success was achieved by spreading dry compost on the wet manure-urine before it was removed. Mr. Frank Smith, Farm Advisor, then suggested spreading a bed of compost after the concrete surface was cleaned and before cows were readmitted.

Recycling Demonstration

From June through November 1970, the project successfully demonstrated the practicality of utilizing the aerobic composting and recycling process in a 90 cow, all-concrete, free-stall facility. (Figure 35).

Tests and calculations indicated it would require about 50 cubic yards of compost, twice a week, to blot the moisture from 90 cows and produce a material with 50-55 percent moisture, which was optimum for composting.

It was further noted that, if there were no breakdown in the process, the two-bin facility would produce the required amount of compost for the 90-cow facility. This estimate proved to be correct and the process continued successfully for the six-month period.

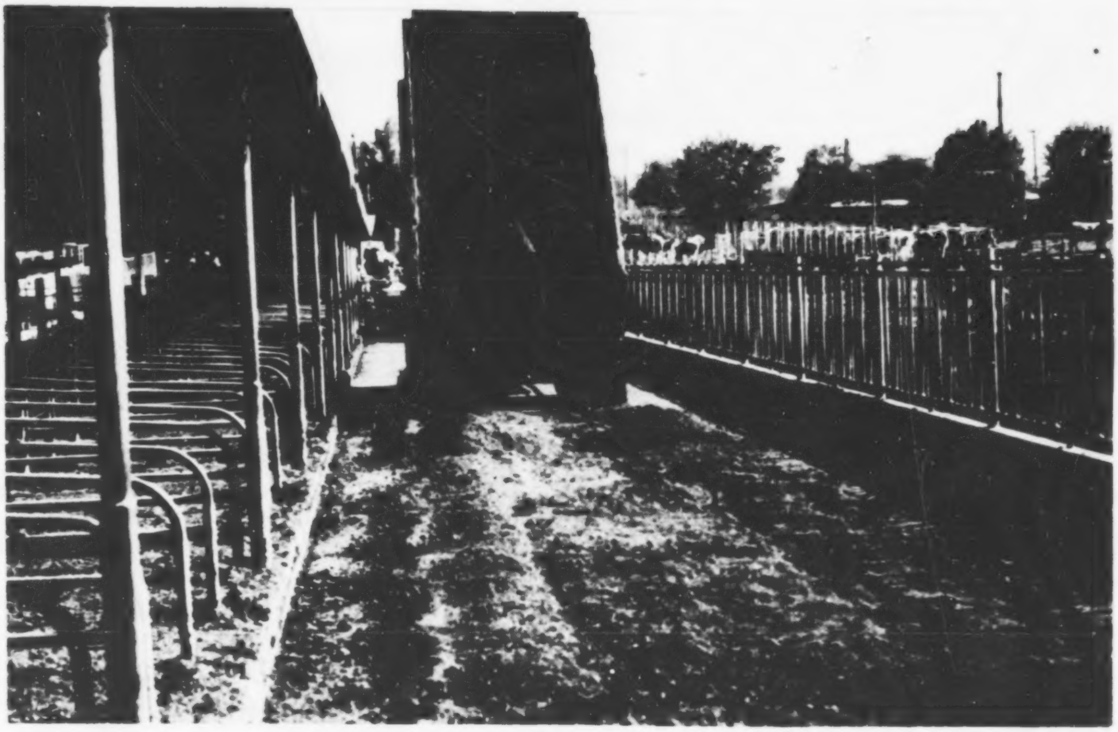

Figure 35. Placing recycled compost in free-stall cow housing facility.

The recycling system is schematically shown in Figure 36. Various types of equipment were reviewed for possible use to minimize time and effort in material handling. One unit was a Sperry-Rand "New Holland" side-unloading manure spreader. This, it was theorized, would be loaded with 10 cubic yards of wet material from the cow housing. The unit would unload onto the aerating pile as it was driven parallel to the aeration pipes. Another unit considered was a self-loading unit which would unload by a snow-blower type system.

Various type tractors, including large, articulator units, were considered. One such unit was demonstrated. With a bucket holding about 3 cubic yards and good speed and maneuverability, this cut time to load and process to less than one-third of the time to load and haul by dump trucks and smaller tractors.

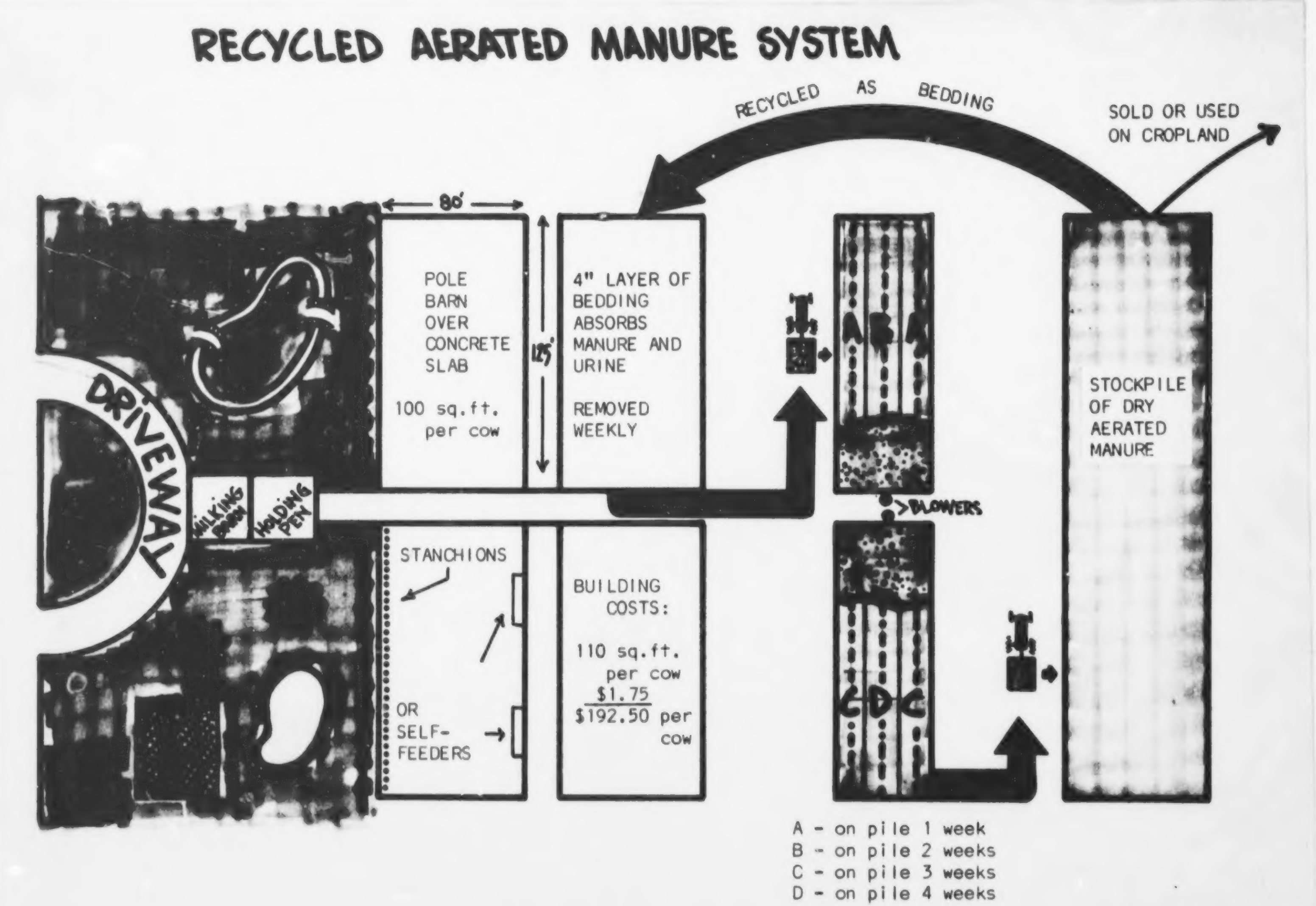

Figure 36. Recycled aerated manure system.

Questions and Problems With "Environmental Cow Housing"

Among the questions to be answered were:

1. Would a mixture of five parts of composted material with one part raw (by volume) contain enough heat-liberating materials to support the rate of thermophilic action which is necessary?
2. Would it be possible to accomplish the moisture reduction from 55 to 25 percent?
3. Would recycling produce a suitable compost?
4. Would recycling result in an excessive build-up of chlorides, etc.?
5. Would labor and equipment time and costs be excessive?

Project's answers to questions:

1. The temperatures did remain high enough but air volumes had to be reduced during the cool weather when night temperatures were in the 32 F to 40 F range.
2. The moisture reduction, in bins, was not as efficient as was expected.

The greatest problem is to remove moisture without creating the air pollution problems associated with most heat drying processes. As stated above, trial was begun in one 90 cow, free-stall, all-concrete unit. Large Holstein cows produce up to 115 pounds of waste per day. With 87 percent moisture this means the dry solids are 15 pounds and the moisture content is 100 pounds.

Material Processing and Handling Capacity

As stated above, it required 50 cubic yards, twice a week, or 100 cubic yards of compost per week for the 90-cow facility. This would indicate need 1.1 cubic yards of compost per cow per week.

Composting Capacity:

With 10-day aerobic composting cycles, need 1.6 cubic yards of composting capacity per cow. For the 200-cow facility need 320 cubic yards of composting capacity.

Aging Capacity:

Since a 30-day aging process is three times as long as the composting process, need 960 cubic yards of composting capacity.

The key items for success were determined to be:

1. Adequate composting capacity, preferably under roof for all-weather operation
2. Adequate and covered (in rainy season) aging piles
3. Careful operation
4. Stand-by composting capacity and equipment.

Conclusions Concerning Environmental Housing

It appears likely that the environmental housing system will provide an answer to the problem of surface and ground water pollution as well as to odors, fly control, dust control, and other environmental problems associated with dairies in close proximity to residential areas. The surplus compost is considerably more attractive and valuable as a soil amendment than the product resulting from composting material from earth corrals. By capturing all of these liquids and solids and converting these into a soil amendment, the otherwise pollutional materials are preserved as a plant nutrient. When applied to soil most of the nitrates are believed to be taken up by the plants rather than penetrating downward to the ground waters.

Preliminary observations indicate that the washing of cows maintained in environmental housing is not quite as difficult as washing cows housed in the earth corrals. In other words, manure appears to be more easy to wash off then certain types of mud-manure mixtures. If this observation is confirmed, it is anticipated that less soaking and washing water will be needed to clean the cows. This should reduce the volume and pollutional strength of the waste water from the cow washing facility. There will, however, remain some polluted water from cows washing and from washing the milking parlor. While this project included some preliminary observations along this line, it did not include indepth studies of the feasibility of treating and recycling this water. At the project site, however, a small scale, batch type, simulated oxidation ditch was utilized with a new type of propeller aerator and use of this system appears promising (Figure 37).

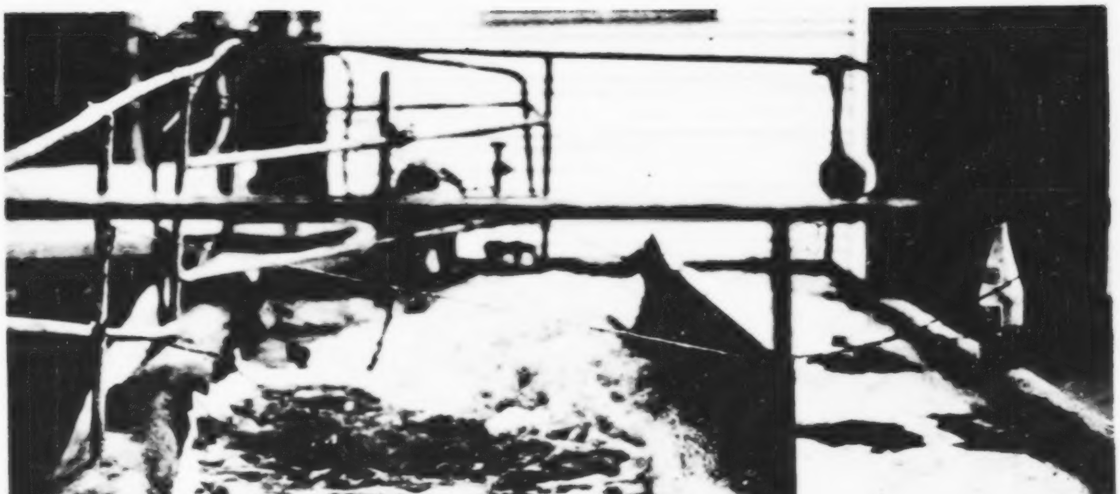

Figure 37. Propeller aerator in simulated oxidation ditch, tested at project site.

CHAPTER 6

ECONOMIC ANALYSIS

Alternate Methods of Manure Management

As stated above, this project was directed primarily toward the management of manure from dairy cows on earth corrals at farms of limited area and in regions which are in close proximity to residential developments. A survey to ascertain attitudes of residents living in the vicinity of such dairies showed that earth corral dairies cause serious complaints from families living closer than 350 feet from a dairy. Flies, odors, and dust were the main adverse environmental factors. The project further recognized that recent water quality control laws, regulations, and policies, plus studies of pollution of aquifers by dairy operation, will necessitate new cow housing and waste management programs and procedures.

The first phase of the project demonstrated that aerated composting of manure from earth corrals is an environmentally and economically practical procedure. Costs and revenue are given in the following tables and discussion. Table 3 covers the operation of the two 133-cubic yard-composting bins. Table 4 gives the lower costs for aerating over pipes installed in open slabs. Economics of the first method are marginal but the second method is clearly economically favorable in areas where there is a market for a quality compost of this type.

TABLE 3

COST OF AERATED COMPOST--DEMONSTRATION PROJECT

Item	Cost	Interest (7%)	Depreciation or Annual Expense	Annual Cost
Bins and blowers	$30,000	$2,100	$3,000	$ 5,100
Eagle Loader truck	15,000	1,050	3,000	4,050
Land (1/2 acre)	3,000	210	200 (tax)	410
Screening facility	3,000	210	300	510
Annual fixed cost--				$10,070
Other annual charges:				
Electricity	$ 120			
Repairs	500			
Gas and Oil	300			
Misc. expense	300			
Office expense	350			
Total--				$ 1,570
Equipment operation and rental, including tractor and trucks (52 weeks @ $60)--				$ 3,120
TOTAL COST (NOT INCLUDING SCREENING LABOR):				$14,760
Screening (2 men, Eagle Loader plus tractor @ $10 per hour) 5 hours per week (20 cubic yards per hour) 52 weeks--				$ 2,600
TOTAL COST FOR BULK COMPOST:				$17,360

Product produced:

100 cu.yds. per week--50 weeks: 5,000 cu.yds.

Cost = $\frac{\$17,360}{5,000}$ = $3.47 per cu.yd. (bulk)

Sacking cost:

Labor per cu.yd. = $1.35

Sacks--13.5 sacks per cu.yd. @ $.12 = $1.62

Total cost sacked product: $6.44 per cu.yd.

Total cost sacked product: $ .47 per sack

TABLE 4

COST OF AERATED COMPOST (OPEN SLAB)

Item	Cost	Interest 7%	Depreciation or Expense	Annual Cost
Slab and blower	$5,000	$350	$500	$ 850
Land (1/2 Acre)	3,000	210	200 (tax)	410
Screen and belt coverage	4,000	280	400	680
		ANNUAL FIXED COST--		$1,940
Other annual charges:				
Electricity		$120		
Repairs		200		
Gas and oil		100		
Miscellaneous exp.		300		
Office expense		300		1,020
Equipment operation and "rental"				2,000
		TOTAL COST (NOT INCLUDING SCREENING LABOR)		$4,960
Screening (See Table 3)				2,600
		TOTAL COST		$7,560

Cost per cu.yd.	$1.43
Sacking labor cost	1.35
Cost of sacks	1.62
Total cost sacked product/cu.yd.	$4.40
Total cost per sack	$0.33

With greater efficiency possible by using methods developed during the project and by purchasing sacks in quantity, the price could be cut somewhat.

The selling price at Alta-Dena Drive-In milk outlets is $.89 per sack and the current wholesale price is $0.65 per sack.

Delivery and marketing costs must be added. The bin process, while not a large scale "money maker", does provide a nuisance-free means of dispensing of manure in all seasons with projected income about equal to costs plus contingencies.

Cost of Processing on Slabs. The simplified method of aerating by a series of perforated pipes in slots in open slabs, has advantages:

1. Reduce construction costs from $30,000 to $5,000.
2. Avoid necessity of purchasing and maintaining Eagle Loader.

In addition, by installing a unit which can both blow and "suck" avoids the necessity of "turning" the material and cuts processing time. After ten days in pile, and while still hot, the material is moved to stockpile for aging. A few aeration pipes under the aging piles enable final, slow composting under aerobic conditions. (Figure 38).

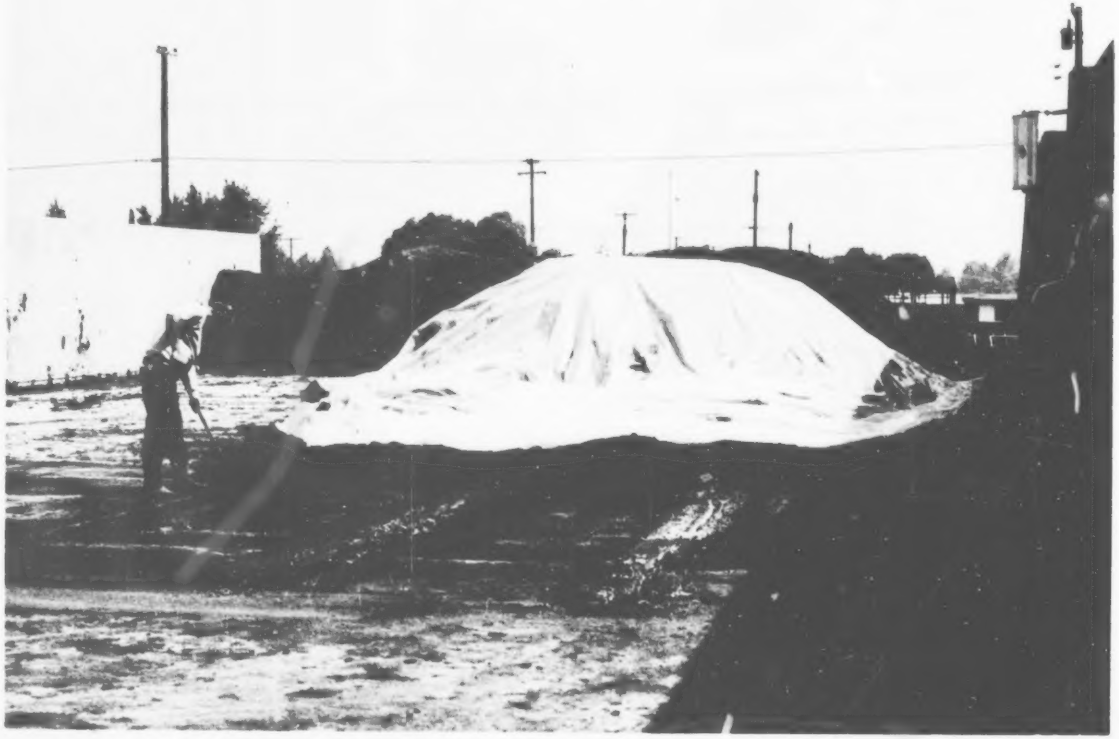

Figure 38. Covering pile while "blowing" to heat outer surface. Also, placing plastic chips over pipes to facilitate airflow.

Costs of the "Environmental Cow Housing System". This method would enable increasing the number of cows per acre. Present practice calls for 500 square feet of corral space per cow. With extra space for maternity and calf pens, hay and feed storage, driveways, set-backs, milking parlors, and space for disposing of milking parlor wash water, 20 cows per gross acre is in some counties a "legal maximum."

With new concerns for nitrate pollution of aquifers, a limit of four cows per acre has been suggested. These factors are of great economic significance where land costs are high.

Mr. Harold Lee, President of the company that built the Alta-Dena Dairy roofed-housing facility used in this project, gave the following current costs for a conventional 400-cow, earth corral dairy in the Chino-Corona area where 115,000 cows are presently being maintained. (See Table 5).

These figures, and cost figures developed during the project, were used in the following to develop an economic analysis.

Comparative Cost Analysis of 400-Cow Facility With Earth Corrals Compared With "Environmental System." In this analysis, the above cost data are used, except that it is assumed that cow density is 80 per gross acre. Land cost is estimated at $5,000 per acre, the current price in the Chino-Corona area. (see Table 6).

TABLE 5

COST BREAKDOWN
400-COW MILKING DAIRY

Ground	"A" Sub Total	$240,000.00
Grading		10,000.00
Irrigation well and pump		9,000.00
Domestic well, pump and tank		7,000.00
Milk house and breezeway		13,000.00
Dairy barn and feed system		22,000.00
Two-hundred cow wash pens		12,400.00
6,000 Gallon tank, 25 H.P. booster pump and controls		2,400.00
Holding pens		1,600.00
Corrals		50,000.00
6-inch concrete driveways		10,000.00
Asphalt paving		5,000.00
Hay shelters		10,000.00
Tractor shed		3,600.00
12-inch concrete lines, standpipes, and alfalfa valves		6,500.00
Barbed wire fencing		6,900.00
	"B" Sub Total	$169,400.00
Vacuum pump, lines, and units		15,000.00
Milk tank, ice machine, etc.		13,000.00
Tractor, wagon, and pickup		16,000.00
	"C" Sub Total	$ 44,000.00
	GRAND TOTAL	$453,400.00

TABLE 6

COMPARATIVE FIXED COSTS OF EARTH CORRAL DAIRIES AND ENVIRONMENTAL SYSTEMS*

400 COW DAIRY

Item	Earth System	Environmental Cow Housing System
Land @ $5,000 per acre	$100,000 (20 A)	25,000
Grading	10,000	2,500
Corral construction, including feed mangers	50,000	10,000*
Driveways	15,000	5,000
Fencing	6,900	2,800
Four 100-cow facilities	-	80,000
Paving, pipes, blowers, walls for composting	-	22,000
Office-laboratory	-	2,000
Roof for composting area	-	10,000
Sieving and sacking	-	7,000
Special hauling equipment	-	15,000
Extender aeration system for waste	-	8,000
Misc. tools and materials	-	5,000
Design and contingency	10,000	10,000
TOTALS	$191,900	$204,300

*Net including roofed housing.

The above tabulation assumes there would be front loading tractors and trucks available for both the earth corral and environmental systems. It assumes barn wash water would be disposed of on part of the 5-acre area of that type dairy; that the extended aeration system will enable recycling some wash water and disposal of waste water on a smaller parcel of land. Taxes would be approximately equal though slightly higher for the larger investment in land for earth corrals.

TABLE 7

ANNUAL EXTRA COST OF RECYCLING MANURE

Depreciation--10 year life equipment and facilities, $40,000 @ 10%	$ 4,000
Repairs	500
Electricity	500
Gas and oil	500
Misc. expense	300
Office expense	300
Operator (1/2 time)	4,000
Supervision (1/4 time)	3,000
	$13,100
Cost of cleaning earth corrals and disposal of manure:	
From Table 1	
$7.80/cow/year to scrape and load	$ 3,120
Hauling cost 3,650 cu.yds. @ $0.50	$ 1,825
Cost of cleaning earth corrals:	$ 4,945
Extra annual cost of recycling manure in environmental housing:	$ 8,155

TABLE 8

COSTS AND REVENUE FROM PRODUCT. QUANTITY OF SACKED COMPOST PER YEAR

Assuming a "shrinkage" from the 3/4 cu.ft. produced per cow per day to 1/2 cu.ft. of final product--

The annual output from 400 cows would equal:

36.5 X 200 = 73,000 cu.ft.
or 2,700 cu.yds.
or 36,500 2-cu.ft. bags

Extra cost of sacking:

Costs of sacks, each = $ 0.12
Costs of sacking = 0.10
Total: $ 0.22 per sack

Estimated value of sacked product
F.O.B. dairy = $ 0.50
Extra cost per sack = 0.22
Revenue per sack: $ 0.28

With 36,500 sacks, revenue over cost = $10,220

Extra annual cost of "environmental
housing system (Table 7) = 8,155

Apparent cost advantage of Environmental
System (per year with 400-cow dairy): $ 2,065

Conclusions of Cost Analysis

The financial comparative analysis depends upon a number of factors. Lower land cost and lack of market for the product would tend to lessen the advantages of the "environmental system."

Further limitations on cow density on earth corrals will tend to favor the environmental system.

When pollution control regulations prohibit surface and ground-water pollution, many of the earth corral dairies will be forced to provide roofed housing. Then the present choice seems to lie between "environmental housing," and a system for treating and disposing of liquid wastes, such as a "dairy" sewerage and treatment plant system.

A comprehensive cost-benefit analysis would, of necessity, include the factors of total environmental impact of various candidate systems. Environmental housing ranks high in odor, fly, and other environmental quality control indices. There are indications that the system has other advantages, especially over earth corral systems, such as:

1. Cow milk production stays high during rainy weather and muddy corral conditions, which results in loss in production.
2. Cow health is probably higher since they are not exposed to muddy corrals which seem to promote mastitis.
3. Cow cleaning is less of a job than when cows lay in muddy corrals.
4. Time and effort to round-up cows and drive to and from milking parlors is reduced.
5. There are indications cows' feet remain healthy, while wet concrete does appear to cause some sore foot problems.

Anticipated Possible Economic Disadvantages. The market for the compost can either improve or decrease the economic advantages.

The necessity for continuously maintaining the system is, like all other parts of an operation which must continue for 365 days a year, an important consideration. However, the project design contemplates enough aeration capacity, in several separate units, that the operation will be continuous. It is also important that a surplus of compost be maintained to carry the operations through periods of adverse weather, etc.

There is the possibility that breakdown of key hauling equipment will necessitate equipment rental or contracting for certain services. This, however, is a problem with any anticipated system, although not as acute.

CHAPTER 7

SPECIAL FINDINGS AND VARIANCES WITH "LITERATURE"

Merits of Demonstrated Aeration Process

The Solid Wastes Office's project review panel wisely had advised that the project include a study of all available methods of utilization or disposal of dairy waste. The data indicated that aerobic composting appears to be the method of choice. Three factors were important in the decision making process. It was determined that the selected process should not necessitate accumulating large quantities of manure for anaerobic composting by stockpiling; the method should be environmentally acceptable, particularly from the standpoint of flies, odors and dust; and the process should produce a product with maximum marketability. An important consumer demand is that the product should be free of weed seeds, dry enough and of such consistency as to facilitate application in a uniform manner to gardens and lawns; that it should not produce objectionable odors nor create fly breeding when subsequently moistened.

The findings of the project are at variance with opinions and decisions based upon other research. For instance, "American Composting Concepts," published by the Environmental Protection Agency Solid Wastes Management Office (1971) said "forced aeration was shown to be technologically difficult to accomplish and was least likely to aerate a composting mass." It said, "simple turning was shown to be an effective way of maintaining needed aeration." These two statements are completely disproven as a result of the project findings, as follows:

In the early stages of the project, masses of approximately 6 cubic yards of manure in each of six bins were turned with a front-end loading bucket. Three simple tests were used along with the visual observation to check various stages in the processing cycle. One was to note the percent of oxygen in the gases within the compost mass. The second was use of 1-, 2-, and 3-foot-long stems on direct reading thermometers. These two sets of data enabled correlating temperatures and percent oxygen. The third test was a rapid moisture determination.

Since the fundamental object of the project was to develop a method for rapidly producing good quality compost at the lowest cost, it was determined that the ideal method would be one in which the entire mass is being processed simultaneously, at a rapid rate. It was found that with relatively fresh manure, or manure and compost mixtures and no aeration, the percent oxygen gradually drops from 20.8 percent at the surface to 6 percent at 18 inches, and near zero at greater depths. The surface temperatures were, as might be expected significantly modified by the atmospheric temperature, but close to ambient temperature. At a depth of 6 inches to nearly 18 inches the temperatures were in the range from 140 F to 160 F, which was considered optimum for producing weed-seed and pathogen-free compost and for maximum composting activity. Even with daily turning it was noted that oxygen at depths below 18 inches quickly dropped to below 6 percent and aerobic processing practically stopped. On the other hand, it was found to be simple to adjust the air supplied by perforated pipes connected with low pressure blowers to maintain a rate necessary to maintain aerobic conditions throughout the mass and without producing excessive cooling effects. It is relatively simple to demonstrate that aerating with a forced or sucked air supply requires far less labor than for windrowing. In other words, the DWMP demonstrated the value of utilizing low pressure air for aerobically composting large masses of cow manure, by a simple and inexpensive system.

Microbiological "Seeding." Another statement in "American Composting Concepts" contends that microbiological "seeding" is of no value in the composting process. One of the more important tests regularly conducted by the project's entomology team was to determine whether or not the compost, when moistened to the optimum fly breeding range, would produce fly larvae when exposed to ova position of fertilized adult females. It was found that two batches of compost could be processed for the same period at well above 140 F, and one would produce flies when subsequently wetted and the other would not. One would produce considerable odors when wetted, the other would not. Preliminary experimentation indicated that the difference was that one batch contained at least 10 percent of compost mixed with the raw manure and the other did not. Subsequently, one bin was filled with over 100 cubic yards of raw manure to which no compost had been added. The second bin was, at the same time, filled with raw manure in which 10 percent compost had been mixed. Both were processed by the same method, simultaneously. Both developed the same temperatures (above 160 F) and appeared to be processing at an equally effective rate. The mixture, however, produced a brownish compost of the appearance and consistency that was desired. Raw manure produced a yellowish material that looked pretty much like dry manure fibres. The material resulting from the mixture, when moistened, remained relatively odorless and did not produce fly larvae, whereas the raw material, when subsequently wetted, did produce odors and fly larvae.

Composting Temperatures

A review of the literature revealed that a number of authorities advocate that temperatures be kept in the 130-140 F range, "to avoid inactivation of beneficial organisms." The project demonstrated that the most rapid production of attractive, stable compost occurred at temperatures between 160 F and 174 F. These temperatures are also desirable to rapidly inactivate weed seeds and pathogens. This observation is in agreement with those of German scientists who visited the project and reported 172 F to be optimum. A major objective in the project was to achieve moisture reduction. This is facilitated by maintaining optimum heat liberation to enable maintaining high temperatures and simultaneous high airflow rate.

Temperatures rose to as high as 188 F. The compost, at temperatures above 174 F, had a nearly black color, a "cooked" odor, and was not a desirable product.

Temperatures and Processing in Open, Aerating Piles. When material was piled over pipes in the manner shown in Figure 38, the temperatures normally reached and were maintained at close to 160 F to within 4 inches of the surface. While there was condensation at the sides, next to the walls of the bins and at the top, there was less evidence of surface condensation in the edges of the open piles.

While "packing" was common in the bins, necessitating moving to the second bin to break up and enable adequate airflow this condition was less of a problem with the piles. In fact, when loaded with material with less than 55 percent moisture, no turning was necessary except that which occurred when the material was moved to the stockpile.

Material which was effectively processed at temperatures above 140 F for approximately eight days would remain at about 140 F for several weeks in the stockpiles. Such temperatures, unlike in piles of unprocessed materials, existed throughout the piles. This condition was believed to inactivate weed seeds and pathogens of most of the portions of the material which was not exposed to high enough temperatures due to their location near the bottom or sides in the composting bin or pile. The aging improved the appearance of the material. A combination of aging plus exposure to the air while placing in and removing from the aging stockpile usually produced a moisture reduction of 5 to 10 percent. This confirmed statements found in the literature calling for "aging" or "ripening" by storage.

Observations of Other Systems

Water-Flushed Dairies. Three water-flushed dairies were studied as part of the project. These were the:

Henry Hafliger Dairy, near San Jacinto, Riverside County (Figure 39)
Shady Grove Dairy, near Ontario in San Bernardino County
Dawn Dairy, near Corcoran in Kings County

At both the Hafliger and Shady Grove Dairies, cows were held in a paved area where they were subjected to washing and soaking by sprays comparable to those used for watering golf courses. The wash water, together with water used to wash the milking parlor, accumulated behind a bottom-hinged dam at the bottom of an approximately 15-foot-wide, 15-foot-long ramp with the water depth ranging from 18 inches at the dam and 0 inches at the top of the slope. Measurements by the Project Director indicated a daily water use of 40 to 50 gallons per cow. It appeared that the sprays were allowed to run more than

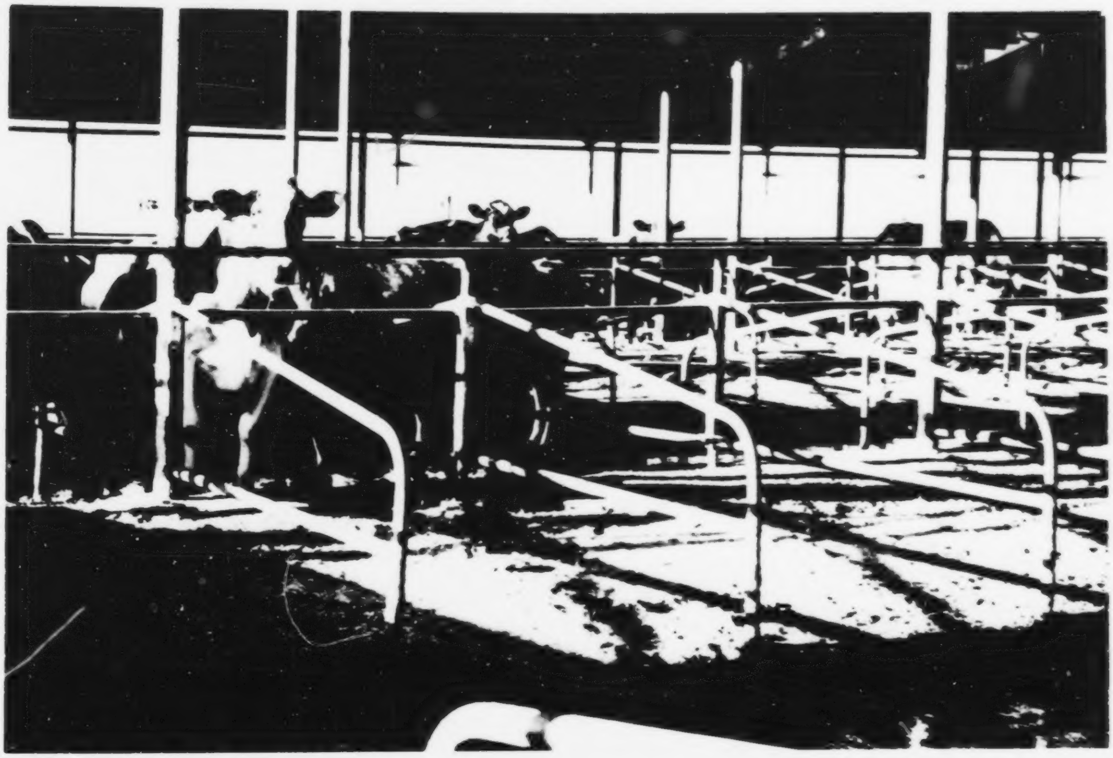

Figure 39. Free-stalls with manure fibre for bedding--Hafliger Dairy.

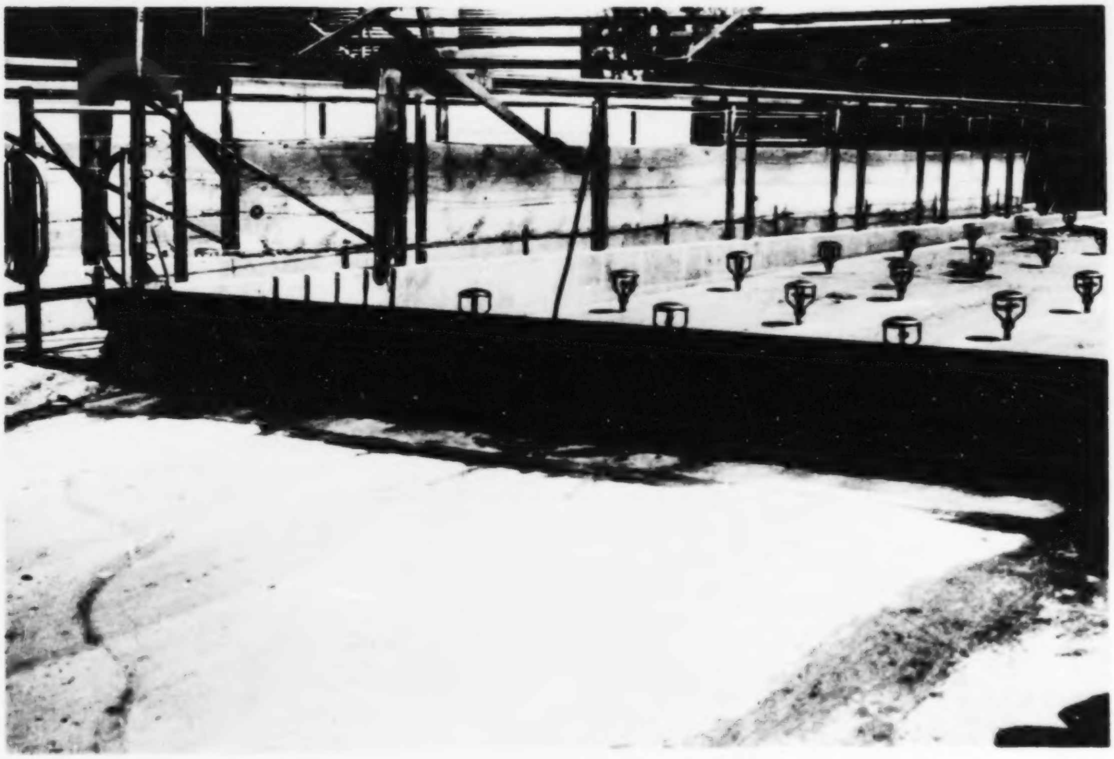

Figure 40. Cow washing nozzles and bottom-hinged dam, for water-flushed dairy.

necessary for cow washing, to accumulate the quantity needed for each flush (at least twice per day) which ranged from 1,100 to 1,500 gallons per aisle. The aisles were about 15 feet wide and 600 feet long (Figure 40).

In both of these dairies the manure-water mixture ran into a sump from which it was periodically pumped.

At the Hafliger Dairy, a "Swego" shaker screen was mounted at an elevation of about 15 feet above the sump (Figure 41). This would remove the fibrous material which dropped into a dump truck. This was used as bedding in the cows' free-stalls.

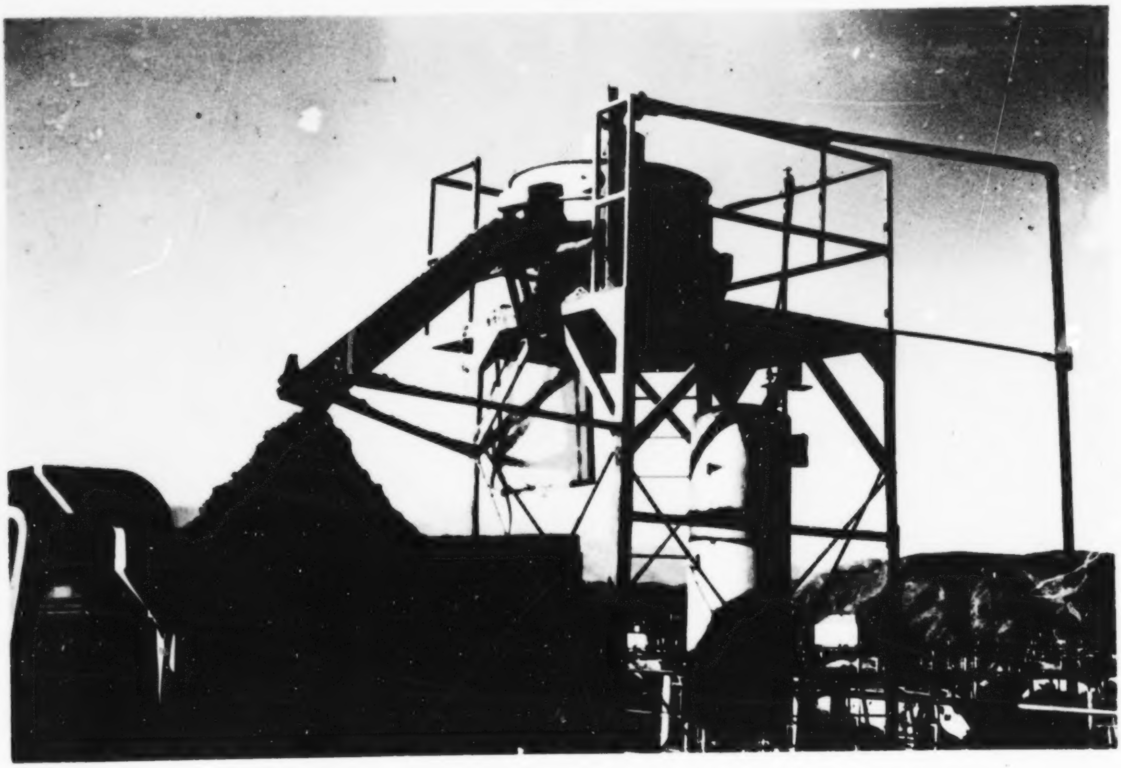

Figure 41. "Swego" shaker screen for waste from Hafliger water-flushed dairy. Fibrous material used for cow bedding.

At times, the screen was bypassed. Then the manure-water mixture was pumped at high pressure through a rotating nozzle which spread the material in a 300-foot-diameter circle. Since there were no nearby residences and there were several hundred acres of land available, the waste disposal posed no immediate problems. The system appears to be efficient, necessitating almost no labor for manure handling. Mr. Hafliger contends he has no special problem with cows' sore feet and no abnormal rate of cow replacement. Some observers contend somewhat of a sore foot problem does exist.

At the Shady Grove Dairy the mixture of water and manure, without treatment, from over 600 cows was spread on about 20 acres of crop lands. The soil had become water-logged and liquid periodically drained into roadside ditches. A shaker screen was installed and it did not seem to solve the problem, but it has not been in use long enough for full observation. A review of these systems (Shady Grove and three others in San Bernardino County) with Health and Farm Advisor officials indicates there are significant problems which will necessitate major modifications or abandonment of the water-flushed systems.

Problems with fly breeding in this type system are described in Appendix 2.

At the Dawn Dairy, with upwards of 1,200 milking cows, a Swego shaker screen provides bedding for the free-stalls. In view of the cows being housed in a fairly clean environment, and where cows' hides are not soiled by mud, a low-volume, efficient cow washing unit is in use. It is using water only when activated by a cow being held momentarily while jets from below wash the essential areas. This saving in water, however, is not significant because of the volume of water used to accomplish the twice daily flushing of the concrete areas between cows' free-stalls and their feed mangers. Extra water is run into the typical ramp-dammed area. In addition, watering troughs which hold about 1,000 gallons each, are provided with bottom-hinged dams which are also routinely opened to flush the paved areas.

The Dawn Dairy liquid waste is utilized, as part of the irrigation water, on over 1,000 acres. The management has reported the "fertilizer" value of this manure is about $165 per month. At the other water-flushed dairies, manure removal labor is minimal. The design overcomes some of the problems of other dairies.

Grooves about 1/8-inch wide and deep, to avoid a slippery surface, are parallel to the slope and tend to drain. At other dairies the grooves are perpendicular to the slope and tend to remain more wet, possibly contributing to the tendency toward sore cows' feet.

Another feature is the surface is slightly crowned to tend to concentrate the flow in the hard-to-clean corners, thereby tending to avoid accumulations of fly-breeding manure at these points.

The above and other observations made during the project have clearly indicated that water-flushed dairies are capable of being maintained with a minimum of labor and nuisances. The major problem is in disposal of the rather large quantities of polluted water, as was discussed in Chapter 4.

Other Systems

Two other systems were observed in the Central Valley of California. Three dairies were designed to continuously keep cows under roof. About 100 square feet of floor area was provided per cow. The areas in front of feed mangers and watering troughs are physically separated by fence, from a larger "loose housing" area where cows sleep and "loaf". Wood shavings and sawdust covered the entire floor. Additional sawdust and shavings are periodically added to the surface. Before accumulations get too deep the mixture of wood waste and manure are removed.

Heavy concentrations of fly larvae were noted in the pile of material which had been removed from the cow housing facility. The system had sufficient promise as to lend encouragement to testing a system in which a more readily available drying material (aerobically processed compost) would be used and in which the immediate processing of water material would avoid fly breeding.

Lagoons. A few new dairies near Tulare were built to provide fairly large lagoons for storing and treating liquid dairy waste. One type design was developed to provide good slopes for corrals in an area of flat terrain. Lagoons are dug to a depth of about 30 feet, about 40 feet wide and 200 feet long. The excavated earth is used to build a mound, on the top of which is the milking parlor. Sloping downward are the corrals and a concrete apron which slopes down to the lagoon. Cow and barn wash water flow down the ramp to the lagoon.

The lagoon serves as a storage reservoir from which the water-manure mixture can be pumped at times when needed for irrigation or when it can be disposed of.

A few special observations were made. While the lagoons, in a somewhat sandy-loam soil, leaked heavily when first filled, they quickly became nearly watertight. It is assumed the ingredients in manure have a tendency to clog pores between the grains of earth.

Contrary to expectations, even though the lagoons were bubbling due to digestive action, they did not produce seriously objectionable odors. Clumps of sludge rose to the surface. Grass tended to grow on these accumulations, partially covering the surface. Some dairymen maintained flocks of ducks with clipped wings. These tended to feed upon and break up the clumps, keeping the surface quite free of such accumulations.

Drainage Problems

At several dairies in the more congested areas near Los Angeles, serious drainage problems were noted. At one water-flushed dairy, it was noted the required 2 to 3 percent slopes for the 600-or-more foot-long concrete free-stall facilities necessitated differences in elevations of 20 feet from bottom to tops of the slopes. The natural slope was about 1 percent. The required slope was produced by excavation at the bottom and filling at the top. In one of several of such dairies observed, the result was that about 15 acres of the dairy property, including barns and roofed and paved areas, drained into sumps which normally received the manure-water mixture from the water-flushed system. During storms the mixture of rain water, manure, and barn drainage all had to be pumped for disposal. With a periodic rainfall rate of 2 inches per hour the pumps must handle 30 cubic feet per second or 13,500 g.p.m., a truly large pumping task. A 6-inch rainstorm would produce 2,500,000 gallons of somewhat polluted water to dispose of. The observations indicated the desirability of a design which would exclude clean drainage from the more polluted drainage the system is designed to handle.

APPENDIX 1

ENVIRONMENTAL EFFECTS OF EARTH CORRAL DAIRIES IN RESIDENTIAL AREAS

by

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Roy Eastwood, R.S. **

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with major input of data from additional surveys in
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APPENDIX 1

INTRODUCTION

Increased human populations, urban expansion problems and environmental pollution in recent years have broadened the scope of public health. "Subsequent definitions (Anon, 1968) have expanded the concept until it encompasses all aspects of societal and individual health and well being." A task force from Health, Education, and Welfare (HEW) (1967) states that "...the department's purpose for environmental concern be to insure that every American can thrive in an attractive, comfortable, convenient and healthful environment."

Southern California has experienced a wide variety of problems associated with rapid urban growth. Residential areas have sprung up with rapidity. Towns have grown and expanded until their borders touch. Agricultural establishments have become surrounded by residential areas adjacent to their borders.

The specific type of situation with which this study deals is the one resulting when people purchase homes adjacent to or near a dairy ranch. Ordinarily there are no buffer zones between the dairy ranches and the residential neighborhoods. In most instances, the purchaser has not been fully aware of the potential problems of having a dairy for a neighbor.

The objectives to be accomplished in this study are as follows:

1. Interview selected citizens to determine what features of dairy farming are particularly objectionable.
2. Determine whether dairy operations carried out under "ideal" conditions with a minimum of fly production and odor nuisance would be objectionable to residents.

METHODS AND MATERIALS

The above-mentioned tasks were accomplished by interviewing residents living around dairies both in Orange and San Bernardino Counties. The San Bernardino County Health Department was very cooperative in this endeavor. A survey form was developed (appendix 1). Residents were interviewed in control areas[1] and in neighborhoods surrounding dairies.[2] In these interviews, the attitudes of the respondents toward environmental nuisances thought to be associated with dairy ranches were measured. Attitudes toward nuisances such as dust, noise, rodents, unsightly premises, odors, and flies were recorded. Also, a "normal" index of attitudes toward these same environmental nuisances was obtained from neighborhoods without any animal establishments (controls) both in Orange and San Bernardino Counties. This index of "normal" attitude levels was then compared to the attitude levels found to be existing in the neighborhoods surrounding dairies. It was then determined whether living close or adjacent to a dairy does or does not create high levels of annoyance toward environmental nuisances and whether these high levels of annoyance would exist regardless of superior dairy management.

1. The control areas in both counties contained no animal or commercial establishments. Also they were about the same socio-economic level as were the dairy neighborhoods.
2. The Orange County dairy neighborhood was chosen because of superior management on the dairy. The San Bernardino County neighborhoods were chosen at random based on similar socio-economic levels.

The dairy neighborhoods were stratified to compare respondents' attitudes in relation to distance from the dairies. A stratified-random sampling plan was adopted. Each dairy neighborhood was divided into three strata:

1. adjacent to the dairies
2. 350 feet from the dairies
3. 700 feet from the dairies.

The houses in each stratum were approximately equidistant from the dairy property. Ten samples were chosen from each stratum.

In Orange County, a letter signed by the city manager of Garden Grove was sent to each respondent introducing the interviewer (appendix 2). The letter did not associate the interviewer with the Orange County Health Department and biased answers resulting from such knowledge were eliminated.

Chi square (χ^2), a statistical method for testing the null hypothesis (that there is no difference) was applied throughout the analysis. The chi square method was chosen because it determines whether groups of samples differ in any respect, i.e., in location, dispersion, skewness, etc. (Siegel 1950).

The following codes will be used throughout the analysis:

C1 = Control neighborhood in Orange County

D1 = Dairy neighborhood in Orange County

C2 = Control neighborhood in San Bernardino County

D2 = Dairy neighborhood #1 in San Bernardino County

D3 = Dairy neighborhood #2 in San Bernardino County

Data Analysis

Dust. In the category of dust, a larger percentage of respondents were annoyed by dust in the dairy neighborhoods than in the control neighborhoods (Table 9).

Although only 27 percent of the respondents in the Orange County dairy sample were annoyed by dust (Table 9), 62 percent of these same respondents blamed the dairy as the source (Table 10). This means that although fewer respondents in the Orange County dairy sample were annoyed by dust than in the other dairy samples, a larger percentage of respondents in the Orange County dairy sample blamed the dairy for the dust problem than did respondents in other dairy areas (Table 10).

The San Bernardino County control sample was significantly different from all the dairy samples (Table 9). Therefore, all three dairy neighborhoods' total populations were more annoyed by dust than the San Bernardino control area total population. However, the Orange County control area sample was significantly different (Table 9) from one of the San Bernardino County dairy samples (D2). Therefore, only the D2 area total population was more annoyed by dust than the Orange County control area total population. Thus, the San Bernardino residents from D2 were more annoyed with dust than the residents from either control area.

Noise. A larger percent of respondents were annoyed with noise in the Orange County control (C1) and dairy (D1) samples than in any of the other neighborhoods (Table 9). The C1 and D1 samples were significantly different from D2 and D3 samples (Table 9). This means that respondents in the total population of both C1 and D1 were more annoyed by noise than the total population of D2 and D3. This difference was due to excessive hot-rodding (respondents' reason for noise) in areas C1 and D1 and was not dairy related.

Actually, a very small percentage of the total respondents blamed the dairies as the source of noise (Table 10). Out of 36 respondents who complained of noise discomforts in their neighborhoods, only 14 percent blamed the dairies as the source (Table 10).

The San Bernardino County control sample (C2) was significantly different from only one of the San Bernardino County dairy samples (D3) (Table 9). This means that the total population in C2 was more annoyed with noise than the total population of D3. A very small percentage of respondents in D3 were annoyed by noise compared to the other areas (Table 9).

Rodents. A larger percentage of respondents in the Orange County dairy sample (D1) and in one of the San Bernardino County dairy samples (D3), were annoyed with rodents than were respondents in any of the other samples (Table 9).

Although there was no significant difference between areas D1 and D3 in respect to the percent of respondents who complained about rodents, (Table 9), 55 percent of the respondents in the D1 area who complained about rodents also blamed the dairy for the problem as compared to only 12 percent in area D3 (Table 10). Samples D1 and D3 are significantly different from C2 (Table 9). This means that the total population in both D1 and D3 were more annoyed by rodents than the total population in C2.

Unsightly Premises. Although a larger percentage of respondents in C1 and D1 were more annoyed with unsightly premises than were respondents in the other neighborhoods, there were no significant differences between any of the test areas (Table 9).

Table 10 reveals that no respondents blamed any of the dairies as being an unsightly premise.

Odors. There was a large percentage difference between dairy and control samples (Table 9). Respondents were much more annoyed with odors in the dairy samples than in the control samples.

Table 10 shows that the majority of respondents who experienced discomfort from odors identified the dairies as the cause. There was a significant difference (χ^2 test) between the percent of respondents blaming the dairy as the cause when comparing one of the San Bernardino County dairy samples (D3) with either D1 or D2. This means that less people in the total population of D3 blamed the dairy for odors than either the total populations of D1 or D2.

The control samples were significantly different from the dairy samples (Table 9). This indicates the total population of each dairy neighborhood was more annoyed with odors than the total population of either control area.

Flies. There was a large percentage difference between the dairy and control samples (Table 9). Respondents were much more annoyed with flies in the dairy samples than in the control samples. The majority of respondents living around dairies who experienced the discomforts from flies identified the dairies as the cause (Table 10).

One San Bernardino County dairy sample (D3) was significantly different from the Orange County dairy sample (D1), and from both of the control samples (Table 9). This means that the total population in D3 was more annoyed with flies than the total population in either C1, C2, or D1. However, both control samples were significantly different from all three dairy samples (Table 9). This signifies that the total population of all three dairy neighborhoods were more annoyed with flies than the total population of the control neighborhoods.

Figure 47 supports the above evidence that residents around dairy #3 were more annoyed with flies than were residents living around the other dairies (note the straight line for dairy #3 in Figure 47).

Ranking Nuisances. The nuisances in the two control areas ranked the same (Table 13). However, in the Orange County control sample (C1) a tie existed between dust and rodents, and in the San Bernardino County control sample (C2) there was a tie between rodents and odors.

In the San Bernardino County dairy samples, more respondents were annoyed by flies than any other nuisance, while in the Orange County dairy sample, more respondents were annoyed by odors than any other nuisance. Statistically speaking, the percentage difference between respondents who were annoyed by odors and those who were annoyed by flies in any single dairy neighborhood fell in the non-significance range. This means that flies and odors were equally annoying in each dairy neighborhood and that the percentage differences within each sample, reflected in Table 13, between respondents who experienced odors and those who experienced flies were due to chance and are not due to the existence of any real differences between total populations.

It is interesting to note in D1 (Table 13) that respondents in the sample were more annoyed with noise than with flies. Also, respondents were highly annoyed with noise in C1. In both cases, it was due to excessive amounts of hot-rodding. Thus in sample D1, respondents were more annoyed with noise that they identified as mainly non-dairy related than they were with flies which the majority of the respondents reported was dairy related (Table 10).

The nuisances were ranked about the same in each dairy neighborhood based on the percent of annoyed respondents who blamed the dairy for causing the nuisance (Table 14). In this table, dairy neighborhoods #1 and #2 ranked nuisances the same. Dairy neighborhood #3 varied slightly.

Severity of Annoyance vs Distance From the Ranch. In the categories of 350 feet and 700 feet from dairies, no respondents blamed the dairies for being the cause of dust, noise, or rodents. Those respondents who did blame the dairy for these three environmental nuisances lived adjacent to the dairies (Table 11).

In the categories of odors and flies, very little difference existed between distances and the number of respondents who blamed the dairies for fly and odor problems (Table 11). Thus from 350 feet away (from the dairies) and on, odors and flies are the only dairy related nuisances for which respondents actually blamed the dairies as the cause.

However, there are significant differences in the "extremely annoyed" category of odors when comparing the "adjacent" to "350 foot" distance and the "adjacent" to "700 foot" distance (Table 12). The differences between respondents at 350 feet and at 700 feet are non-significant in the "extremely annoyed" category. Total residents living adjacent to the dairies tend more frequently to be extremely annoyed with odor than at the other distances.

There are significant differences (χ^2, 5%) in the "extremely annoyed" category of flies between respondents living adjacent to the dairies and those living at the 700-foot distance away from the dairies (Table 12).

This means that total residents living adjacent to the dairies tend to be extremely annoyed with flies more often than those living at least 700 feet away from the dairy.

Figures 42 through 47 illustrate levels of annoyance in relation to distance, dairy by dairy. Figures 48 and 49 are a composite of Figures 42 through 47. Based on percent of respondents annoyed, as shown in these figures, there are no significant differences between distances. Perhaps with larger sample sizes, there would have been differences on this basis. Figures 46 and 47 for flies and odors is supporting evidence for this statement. (Note the gradual decline as distance increases).

Responses to Miscellaneous Question #1. Near the beginning of the interview schedule, the respondents were asked, "Can you think of anything in your neighborhood which has been particularly annoying or bothersome to you?" This question was designed to reveal what the _first_ annoyance "popping" into their minds might be.

The only comparison of groups which was significantly different was control sample (C2) compared to respondents living 350 feet away from the dairies (Table 15). This means that the total population of residents who live at the 350-foot distance would be more apt to say that something annoyed them about their neighborhood than would the total population of residents living in the San Bernardino control area. Although all the remaining comparisons of groups that can be derived from Table 15 were not significantly different, the other two distance categories (adjacent and 700 feet) were _close_ to being significantly different from the San Bernardino control area and may have been so had a larger size sample been taken.

Respondents' attitudes were significantly different when comparing the (D1) sample with all the other samples in Table 16. These differences were not due to a bad influence of the dairy on its surrounding neighborhood, but were due to respondents around D1 complaining excessively about hot-rodding and street improvements. The high percentage of dairy respondents who fell into the "can think of something annoying" category at the different distances from the dairies in Table 15 were due to the influence of D1 as a whole in the data.

In response to miscellaneous question #1, a certain percent of respondents mentioned either the dairy, flies, or odors as being particularly annoying or bothersome (Table 17). There were no significant differences in any comparison that could be derived from Table 17. However, it is worthy of note that the only groups that had no respondents mentioning dairies as the first annoying thing to come into their minds, in response to the question asked, were the control groups and the 700-foot groups.

Responses to Miscellaneous Question #2. After miscellaneous question #1 analyzed above was asked, the following question was posed to the respondents, "How satisfied would you say you are with your neighborhood: very satisfied; somewhat satisfied; or not at all satisfied?" Each respondent chose one of the three possibilities (Table 18). The only groups significantly different were one San Bernardino sample (D2) compared to the San Bernardino control sample (C2) in the "very satisfied" category. This means that more residents living in C2 would say that they were very satisfied with their neighborhood than would residents living in D2. The fact that fewer respondents were "very satisfied" with their neighborhood in C1 as compared to area C2 could be due to the excessive hot-rodding (noise) experienced by respondents in area C1.

It is worthy of note (Table 18) that all the dairy neighborhoods had fewer respondents in the "very satisfied" category than did C2. Also, no respondents in either control samples were "not at all satisfied" with their neighborhoods compared with at least one respondent in each dairy sample who fell into this category.

SUMMARY

The following conclusions are drawn from the data analysis.

Nuisances

Dust. As a whole, residents living around dairies will tend to complain more about dust than residents living in neighborhoods without animal establishments.

Noise. Residents living around dairies will not complain any more or less about noise than will residents living in neighborhoods without animal establishments.

Rodents. The evidence favors the conclusion that residents living around dairy ranches will complain more about rodents (mainly gophers) than will residents living in neighborhoods without animal establishments.

Unsightly Premises. The evidence leads to the unquestionable conclusion that dairy neighborhood residents will not complain any more or less about unsightly premises than will residents living in neighborhoods without animal establishments.

Odors and Flies. It is an unquestionable conclusion that residents living around dairies complain more about flies and odors than residents living in neighborhoods without animal establishments.

Ranking Nuisances

Residents surrounding dairies will complain about flies and odors at the same rate and will rank flies and odors as the most annoying nuisances. However, residents around the Orange County dairy (D1) complained about noise (hot-rodding) being as bad as the odors and flies. Residents living in areas without animal establishments or other non-residential use will complain about noise (hot-rodding) more than any other nuisance.

The Effects of Distance

A greater number of residents living adjacent to the dairies will say that they are extremely annoyed with flies and odors than will residents living at least 700 feet away. Also, a greater number of residents living 350 feet and on, from a dairy, will be less apt to say they are extremely annoyed with odors than residents adjacent to dairies. In this sense, flies have a more far reaching geographical effect than do odors. However, when comparing percent of respondents annoyed by flies to odors at 700 feet, flies and odors have very nearly an equal effect on residents living at the 700-foot distance.

Satisfaction With Environment

As a whole, residents surrounding dairy ranches are less satisfied with their neighborhoods than are residents who live in neighborhoods without animal establishments or other commerce. This is probably a result of the residents' awareness to the dairy-related nuisances such as flies, odors, and dust.

Effects of Superior Management

The Orange County dairy (D1) was known to be operated with superior environmental management. Considering the effects of this dairy on the residents, as shown in the data analysis, it is reasonable to conclude that even a dairy utilizing superior management techniques is not completely an acceptable neighbor in a residential area.

Conclusions

The final conclusions drawn from this study indicate to the authors that neighborhoods can be surveyed to determine residents' attitudes concerning their environment.

Some apprehension existed as to whether interviewing respondents around the dairies about nuisances would cause the residents increased agitation toward the dairies. No fly and odor complaints from respondents living around the Orange County dairy were recorded by the Orange County Health Department after the interviews were completed. Part of this success may be attributed to a letter of introduction sent to each respondent prior to interviewing.

The writers have also concluded that the two major nuisance problems associated with dairy operations, even with excellent dairy management, are flies and odors. Therefore, it seems imperative that dairies desiring to remain in residential areas must seek out and use new methods of solving these two outstanding problems.

TABLE 9

DISTRIBUTION OF THE PERCENTAGE OF RESPONDENTS ANNOYED BY EACH NUISANCE, ARRANGED TO SIGNIFY SIGNIFICANT DIFFERENCE BETWEEN NEIGHBORHOODS

1. **Dust:**

<table>
<tr><td></td><td></td><td colspan="3">------same------</td><td></td></tr>
<tr><td></td><td colspan="2">--same---</td><td colspan="3">------same------</td></tr>
<tr><td>neighborhood:</td><td>C2</td><td>C1</td><td>D1</td><td>D3</td><td>D2</td></tr>
<tr><td>% annoyed</td><td>3%</td><td>10%</td><td>27%</td><td>30%</td><td>37%</td></tr>
</table>

2. **Noise:**

<table>
<tr><td></td><td></td><td colspan="2">--same---</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">--same---</td><td colspan="3">------same------</td></tr>
<tr><td>neighborhood</td><td>D3</td><td>D2</td><td>C2</td><td>D1</td><td>C1</td></tr>
<tr><td>% annoyed</td><td>17%</td><td>37%</td><td>43%</td><td>67%</td><td>70%</td></tr>
</table>

3. **Rodents:**

<table>
<tr><td></td><td></td><td colspan="4">---------same----------</td></tr>
<tr><td></td><td colspan="3">------same------</td><td></td><td></td></tr>
<tr><td>neighborhood</td><td>C2</td><td>C1</td><td>D2</td><td>D3</td><td>D1</td></tr>
<tr><td>% annoyed</td><td>0%</td><td>10%</td><td>10%</td><td>27%</td><td>30%</td></tr>
</table>

4. **Unsightly Premises:**

<table>
<tr><td></td><td colspan="5">-------------same-------------</td></tr>
<tr><td>neighborhood</td><td>D3</td><td>C2</td><td>D2</td><td>D1</td><td>C1</td></tr>
<tr><td>% annoyed</td><td>3%</td><td>7%</td><td>10%</td><td>13%</td><td>23%</td></tr>
</table>

5. **Odors:**

<table>
<tr><td></td><td colspan="2">--same---</td><td colspan="3">------same------</td></tr>
<tr><td>neighborhood</td><td>C1</td><td>C2</td><td>D3</td><td>D2</td><td>D1</td></tr>
<tr><td>% annoyed</td><td>0%</td><td>0%</td><td>67%</td><td>77%</td><td>80%</td></tr>
</table>

6. **Flies:**

<table>
<tr><td></td><td></td><td></td><td></td><td colspan="2">--same---</td></tr>
<tr><td></td><td colspan="2">--same---</td><td colspan="2">--same---</td><td></td></tr>
<tr><td>neighborhood</td><td>C2</td><td>C1</td><td>D1</td><td>D2</td><td>D3</td></tr>
<tr><td>% annoyed</td><td>20%</td><td>27%</td><td>63%</td><td>87%</td><td>90%</td></tr>
</table>

Neighborhoods not connected by dotted lines are significant at 5% χ^2.

C1 = Orange County control sample
C2 = San Bernardino County control sample
D1 = Orange County dairy sample
D2, D3 = San Bernardino County dairy sample

TABLE 10

PERCENTAGE DISTRIBUTION OF ANNOYED RESPONDENTS BLAMING DAIRY AS THE CAUSE (DAIRY BY DAIRY)

	Dust		Noise	
Area	Number Annoyed	Percent Annoyed Blaming Dairy	Number Annoyed	Percent Annoyed Blaming Dairy
D1	8	62%	20	5%
D2	11	36%	11	9%
D3	9	11%	5	0%

	Rodents		Unsightly Premises	
Area	Number Annoyed	Percent Annoyed Blaming Dairy	Number Annoyed	Percent Annoyed Blaming Dairy
D1	9	55%	4	0%
D2	3	33%	3	0%
D3	8	12%	1	0%

	Odors		Flies	
Area	Number Annoyed	Percent Annoyed Blaming Dairy	Number Annoyed	Percent Annoyed Blaming Dairy
D1	24	95%	19	79%
D2	23	100%	26	92%
D3	20	70%	27	81%

D1 = Orange County dairy sample.

D2, D3 = San Bernardino County dairy samples.

TABLE 11

DISTRIBUTION OF RESPONDENTS MENTIONING A NUISANCE AND IDENTIFYING THE DAIRY AS THE CAUSE (DAIRIES COMBINED, DISTANCE BY DISTANCE)

	Dust		Noise	
	Number Annoyed	Percent Annoyed Blaming Dairy	Number Annoyed	Percent Annoyed Blaming Dairy
Adjacent to dairies	13	53%	16	12%
350 ft. from dairies	7	0%	10	0%
700 ft. from dairies	8	0%	10	0%

	Rodents		Unsightly Premises	
	Number Annoyed	Percent Annoyed Blaming Dairy	Number Annoyed	Percent Annoyed Blaming Dairy
Adjacent to dairies	10	70%	2	0%
350 ft. from dairies	3	0%	4	0%
700 ft. from dairies	7	0%	2	0%

	Odors		Flies	
	Number Annoyed	Percent Annoyed Blaming Dairy	Number Annoyed	Percent Annoyed Blaming Dairy
Adjacent to dairies	24	92%	27	93%
350 ft. from dairies	23	96%	25	76%
700 ft. from dairies	20	80%	20	85%

TABLE 12

SEVERITY OF ANNOYANCE VS DISTANCE FROM DAIRIES (DAIRIES COMBINED)

Severity of Annoyance	Dust			Noise			Rodents		
	Adj.	350'	700'	Adj.	350'	700'	Adj.	350'	700'
Not at all annoyed	57%	77%	73%	46%	67%	67%	67%	90%	77%
Slightly annoyed	10%	3%	0%	0%	3%	3%	7%	6%	17%
Moderately annoyed	20%	10%	23%	30%	10%	20%	13%	10%	6%
Seriously annoyed	10%	10%	4%	17%	20%	7%	10%	0%	0%
Extremely annoyed	3%	0%	0%	7%	0%	3%	3%	0%	0%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%
N =	30	30	30	30	30	30	30	30	30

	Unsightly Premises			Odors			Flies		
	Adj.	350'	700'	Adj.	350'	700'	Adj.	350'	700'
Not at all annoyed	94%	87%	94%	20%	23%	34%	10%	17%	33%
Slightly annoyed	3%	0%	0%	10%	37%	30%	7%	17%	17%
Moderately annoyed	0%	10%	3%	30%	23%	23%	33%	37%	37%
Seriously annoyed	3%	3%	0%	20%	17%	13%	27%	16%	13%
Extremely annoyed	0%	0%	3%	20%	0%	0%	23%	13%	0%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%
N =	30	30	30	30	30	30	30	30	30

TABLE 13

RANKING OF NUISANCES ON BASIS OF PERCENT RESPONDENTS WHO WERE ANNOYED WITH EACH NUISANCE (ARRANGED BY NEIGHBORHOOD)

Control #1 (Orange Co.)		Control #2 (San Bernardino Co.)	
Nuisance	% Annoyed	Nuisance	% Annoyed
Noise	70	Noise	43
Flies	27	Flies	20
Unsightly Premises	23	Unsightly Premises	7
Dust	10	Dust	3
Rodents	10	Rodents	0
Odors	0	Odors	0

Dairy #1 (Orange Co.)		Dairy #2 (San Bern. Co.)		Dairy #3 (San Bern. Co.)	
Nuisance	% Annoyed	Nuisance	% Annoyed	Nuisance	% Annoyed
Odors	80	Flies	87	Flies	90
Noise	67	Odors	77	Odors	67
Flies	63	Dust	37	Dust	30
Rodents	30	Noise	37	Rodents	27
Dust	27	Rodents	10	Noise	17
Unsightly Premises	13	Unsightly Premises	10	Unsightly Premises	3

TABLE 14

RANKING OF NUISANCES BASED ON THE PERCENT OF ANNOYED RESPONDENTS WHO BLAMED THE DAIRY FOR CAUSING THE NUISANCES

Dairy #1 (Orange County)			Dairy #2 (San Bernardino County)			Dairy #3 (San Bernardino County)		
Nuisance	Number Annoyed	% Annoyed Blaming Dairy	Nuisance	Number Annoyed	% Annoyed Blaming Dairy	Nuisance	Number Annoyed	% Annoyed Blaming Dairy
Odor	24	95	Odor	23	100	Flies	27	81
Flies	19	79	Flies	26	92	Odor	20	70
Dust	8	62	Dust	11	36	Rodents	8	12
Rodents	9	55	Rodents	3	33	Dust	9	11
Noise	20	5	Noise	11	9	Noise	5	0
Unsightly premises	4	0	Unsightly premises	3	0	Unsightly premises	1	0

TABLE 15

DISTRIBUTION OF RESPONDENTS' ANSWERS TO THE QUESTION, *"Can you think of anything in your neighborhood which has been particularly annoying or bothersome to you?"*

(Arranged by distance from the dairies--All dairies combined)

	Adj.	350'	700'	C1	C2
Can think of something annoying	63%	70%	63%	47%	40%
Can't think of something annoying	37%	30%	37%	53%	60%
TOTAL	100%	100%	100%	100%	100%
N =	30	30	30	30	30

TABLE 16

DISTRIBUTION OF RESPONDENTS' ANSWERS TO THE QUESTION, *"Can you think of anything in your neighborhood which has been particularly annoying or bothersome to you?"*

(arranged by dairy)

	Neighborhood				
	D1	D2	D3	C1	C2
Can think of something annoying	93%	50%	53%	47%	40%
Can't think of something annoying	7%	50%	47%	53%	60%
TOTAL	100%	100%	100%	100%	100%
N =	30	30	30	30	30

C1 = Orange County control sample
C2 = San Bernardino County control sample
D1 = Orange County dairy sample
D2, D3 = San Bernardino County dairy samples

TABLE 17

PERCENT OF RESPONDENTS WHO MENTIONED THE DAIRY, FLIES, OR ODORS IN ANSWER TO THE QUESTION, "*Can you think of anything in your neighborhood which has been particularly annoying or bothersome to you?*"

(Both by distance and neighborhood)

	Distance			Neighborhood				
	Adj.	350'	700'	D1	D2	D3	C1	C2
Mentioned dairy	17%	10%	0%	10%	7%	10%	0%	0%
Mentioned flies	13%	3%	3%	10%	3%	7%	0%	0%
Mentioned odors	3%	3%	7%	3%	0%	10%	0%	0%

C1 = Orange County control sample
C2 = San Bernardino County control sample
D1 = Orange County dairy sample
D2, D3 = San Bernardino County dairy samples

TABLE 18

DISTRIBUTION OF RESPONDENTS ANSWERING QUESTION, *"How satisfied would you say you are with your neighborhood?"*

(By distance and by neighborhood)

	Distance			Neighborhood				
	Adj.	350'	700'	D1	D2	D3	C1	C2
Very satisfied	70%	63%	67%	67%	57%	77%	77%	87%
Somewhat satisfied	23%	39%	26%	30%	36%	20%	23%	13%
Not at all satisfied	7%	0%	7%	3%	7%	3%	0%	0%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%
N =	30	30	30	30	30	30	30	30

C1 = Orange County control sample
C2 = San Bernardino County control sample
D1 = Orange County dairy sample
D2, D3 = San Bernardino County dairy sample

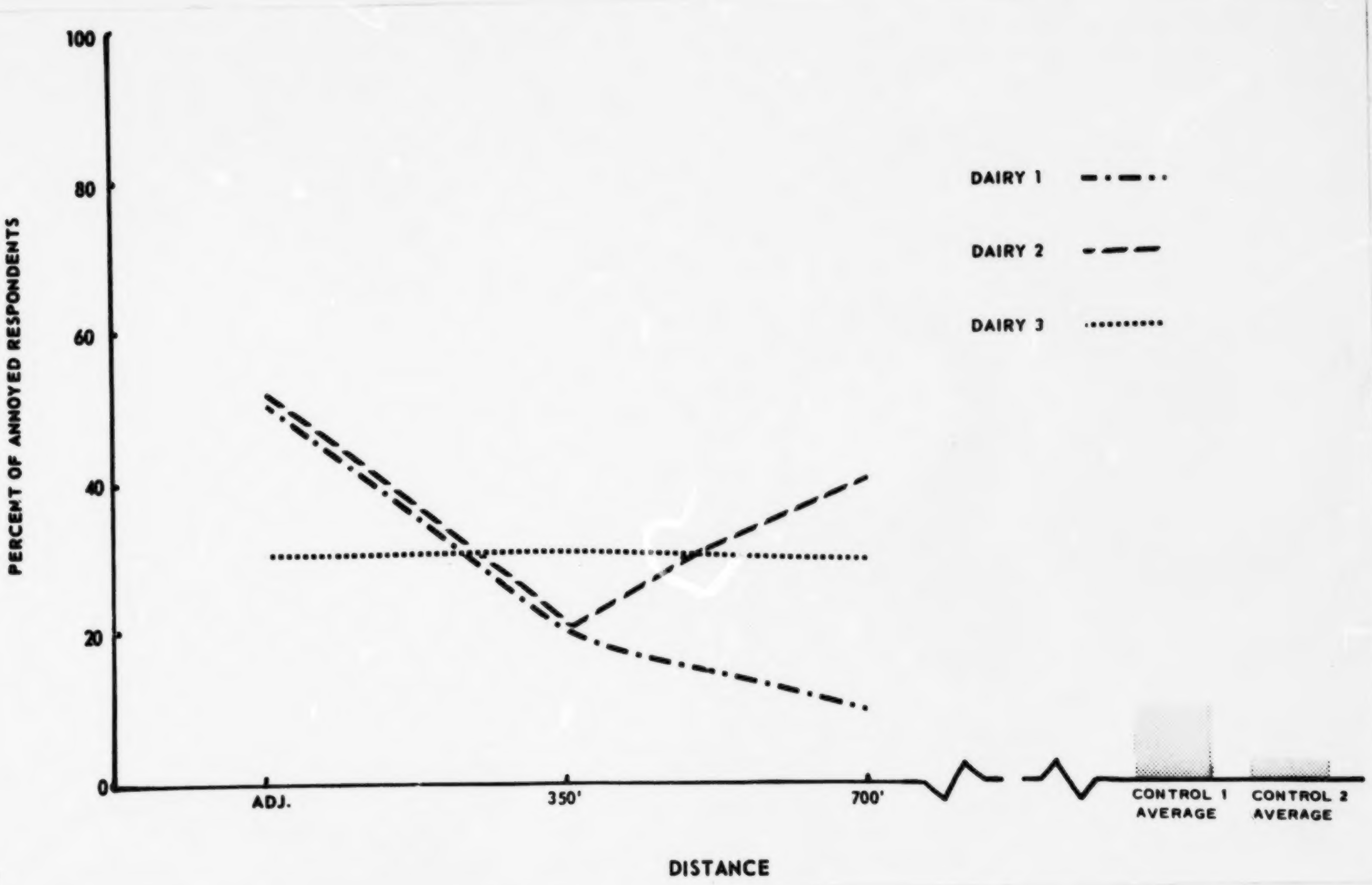

Figure 42. Distance from dairies vs. percent of annoyed respondents--DUST

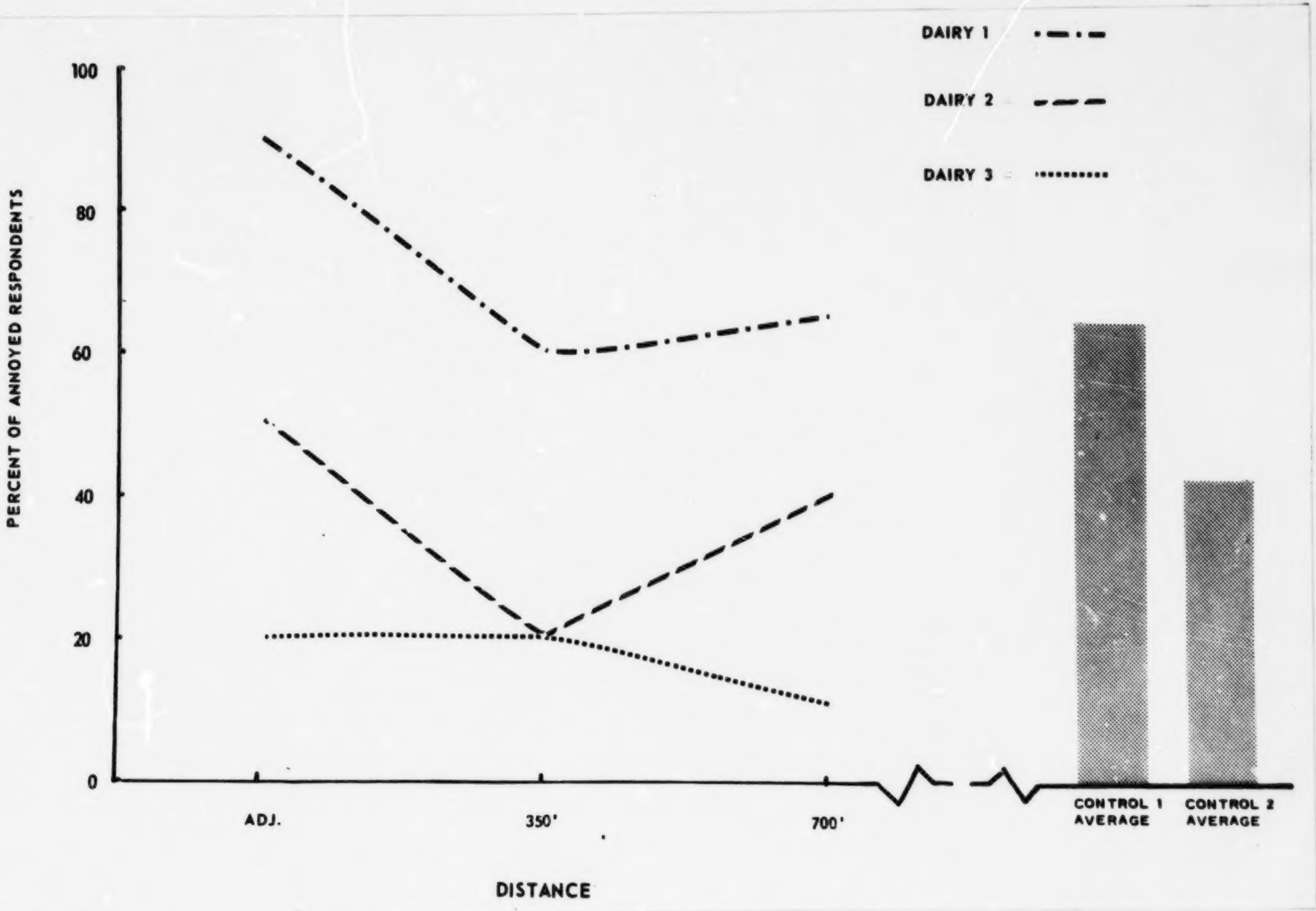

Figure 43. Distance from dairies vs. percent of annoyed respondents--NOISE.

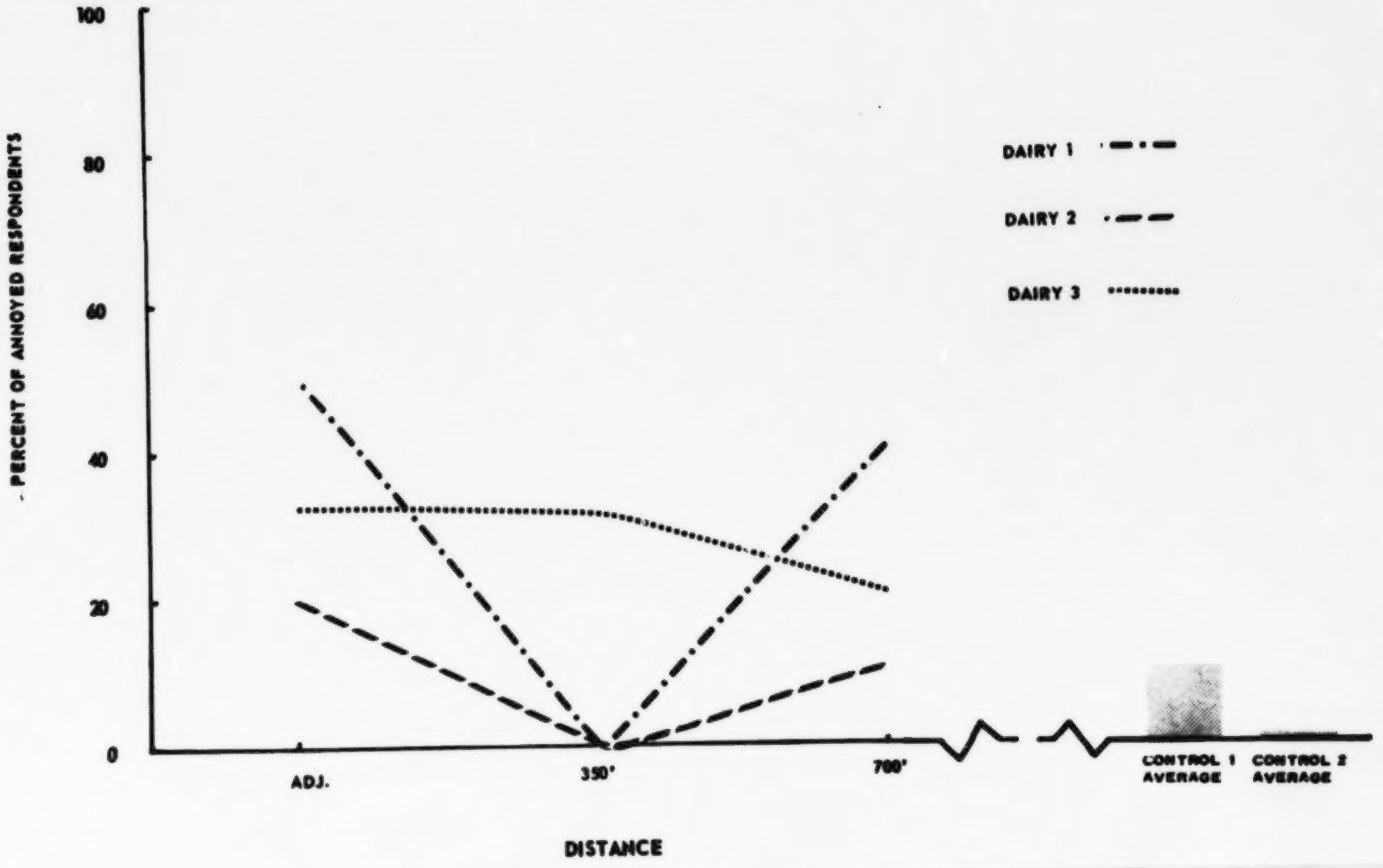

Figure 44. Distance from dairies vs. percent of annoyed respondents--RODENTS.

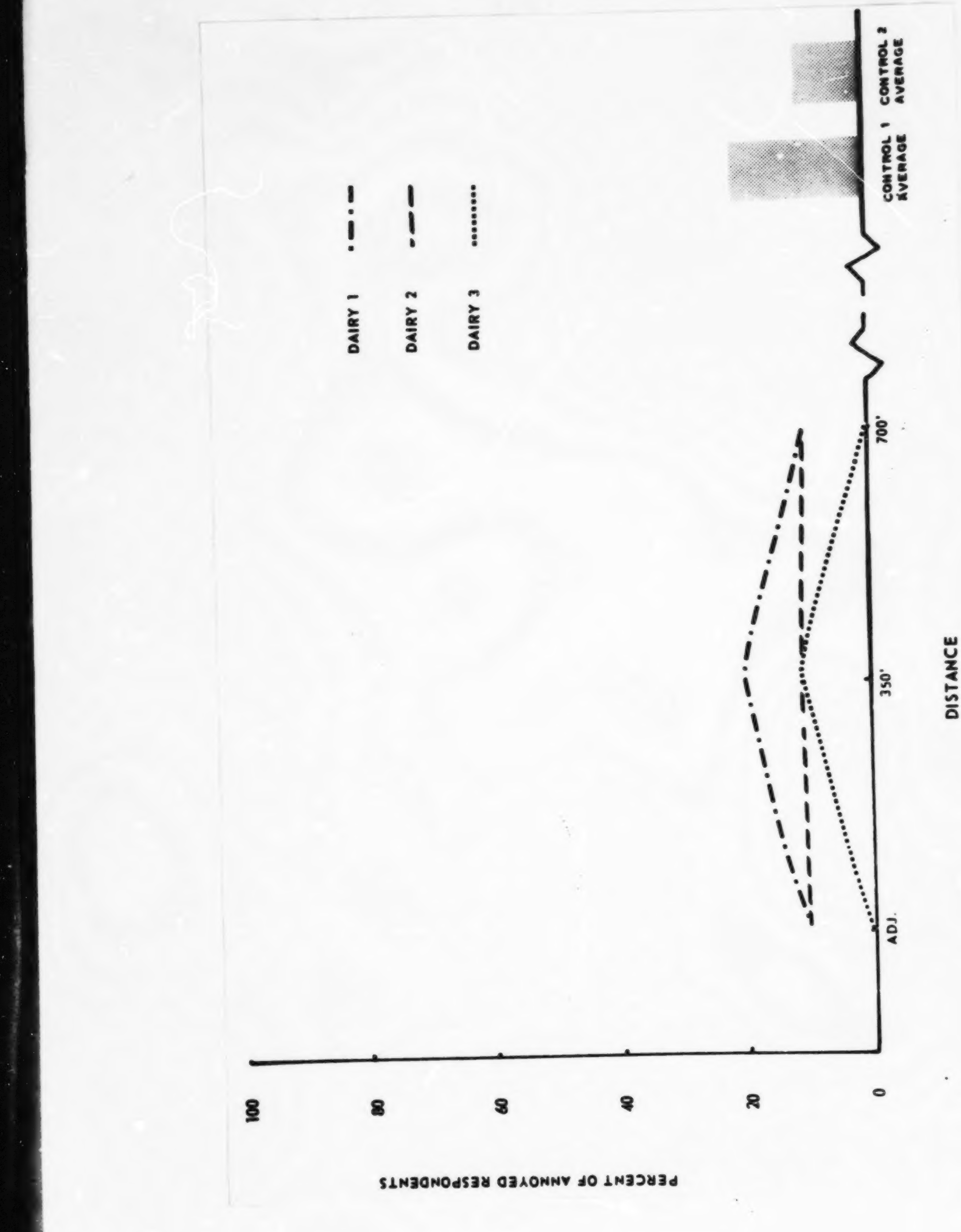

Figure 45. Distance from dairies vs. percent of annoyed respondents--UNSIGHTLY PREMISES.

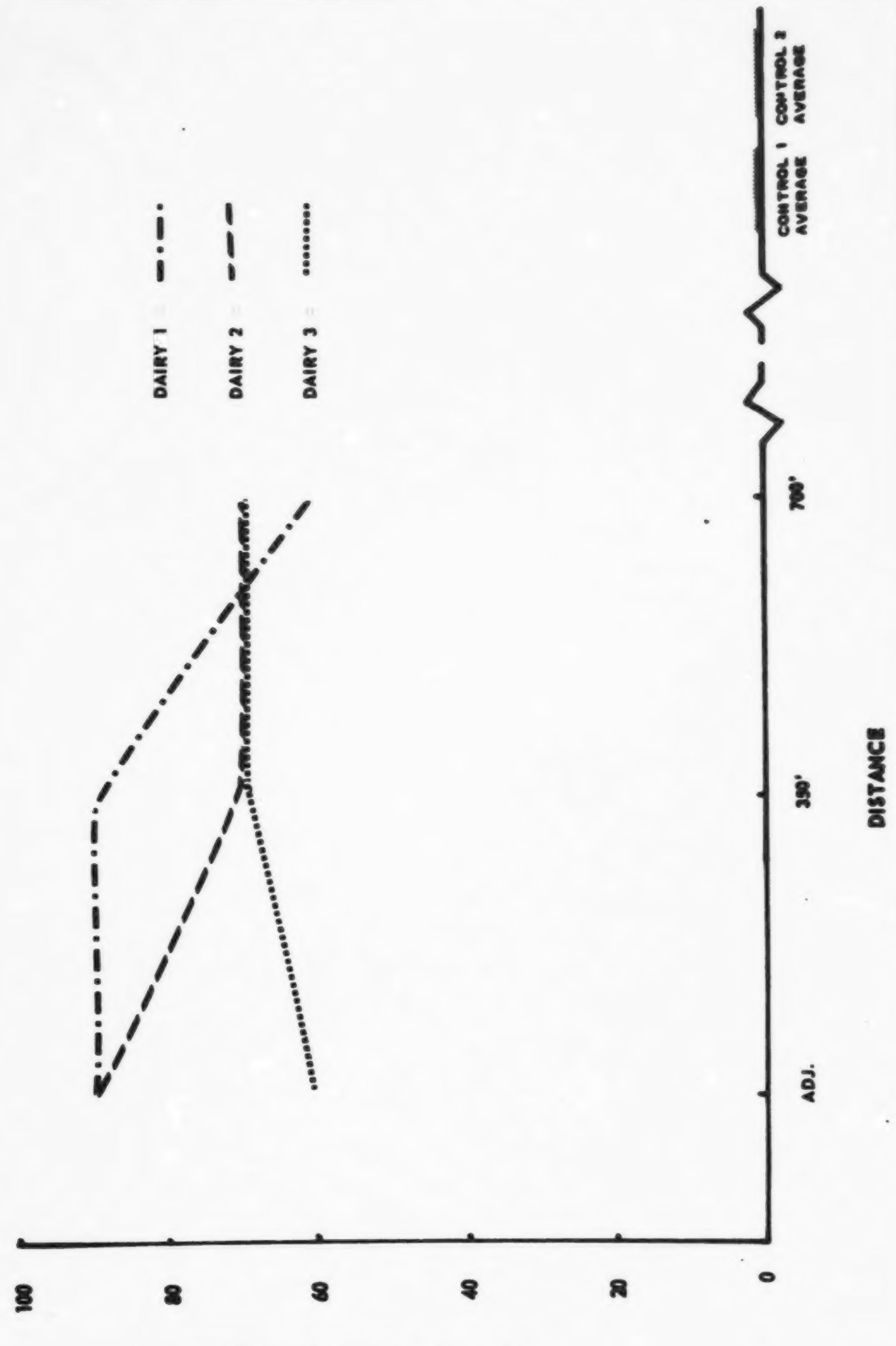

Figure 46. Distance from dairies vs. percent of annoyed respondents--ODORS.

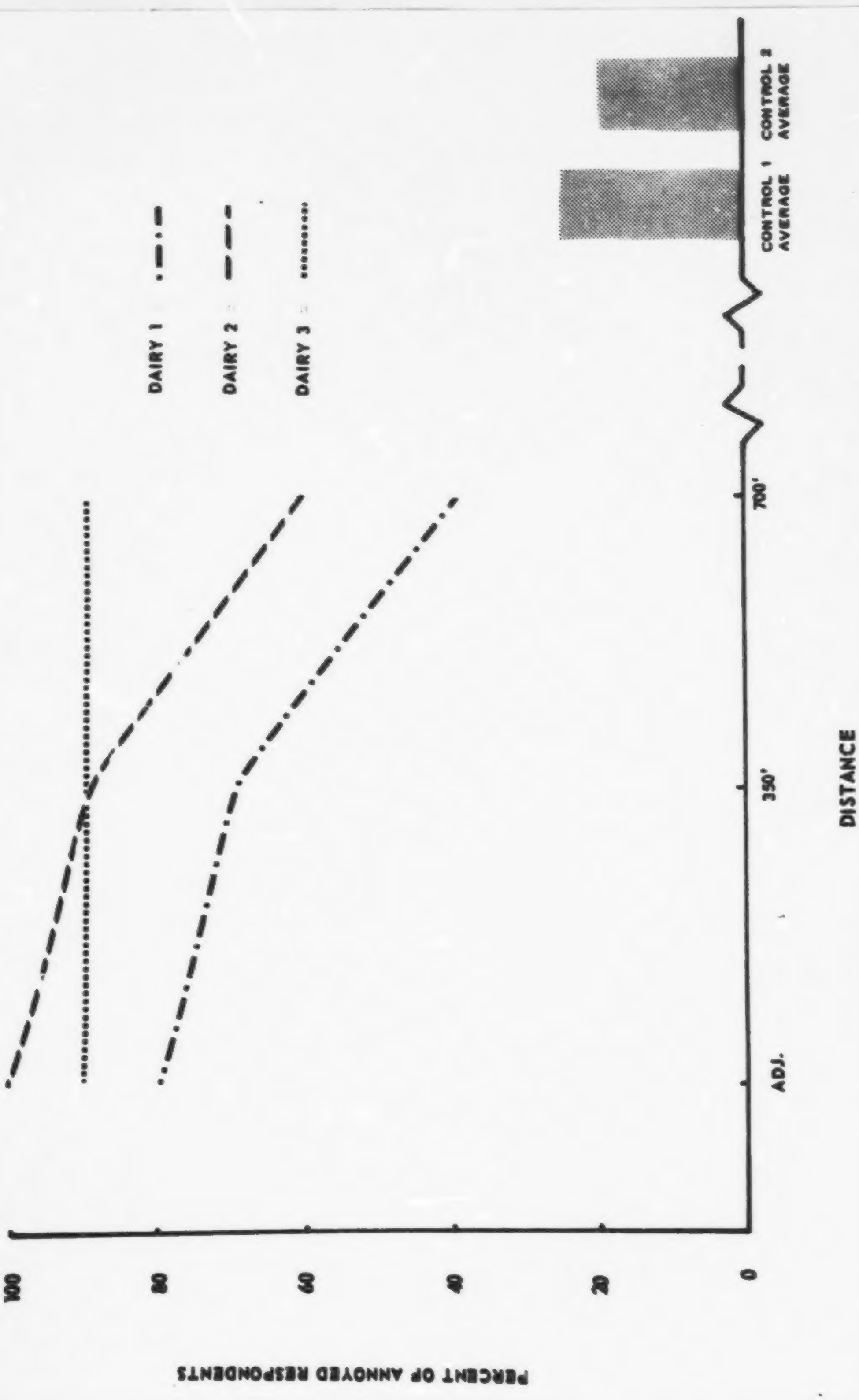

Figure 47. Distance from dairies vs. percent of annoyed respondents--FLIES.

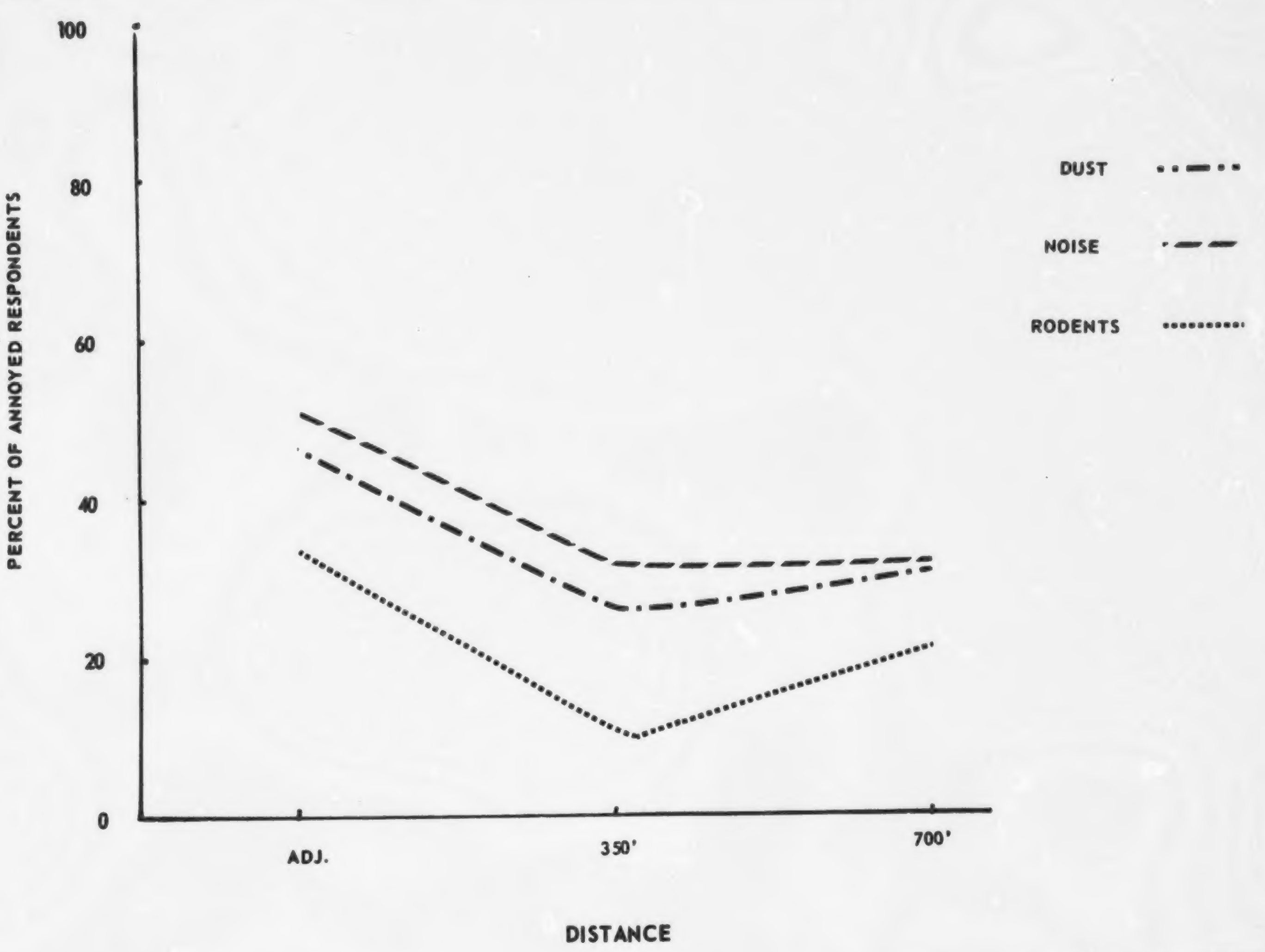

Figure 48. Distance from dairies vs. average percent of annoyed respondents (dairies combined)--DUST, NOISE, RODENTS.

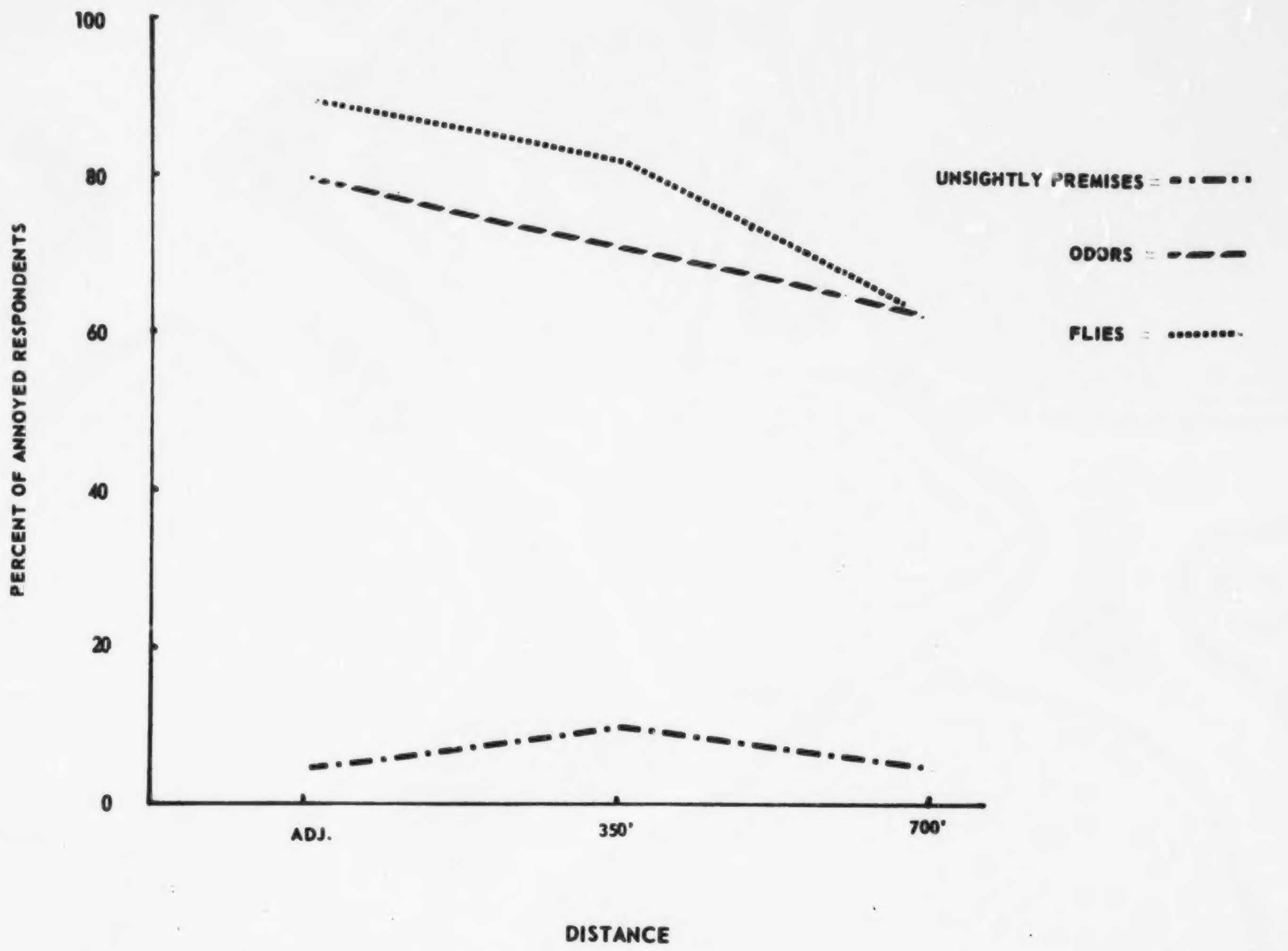

Figure 49. Distance from dairies vs. average percent of annoyed respondents (dairies combined)--UNSIGHTLY PREMISES, ODORS, FLIES.

QUESTIONNAIRE - NEIGHBORHOOD SURVEY

C1 ______ Time Begin
C2 ______ Time End
C3 ______ Case No. ______ Total Time
C4 ______ Cluster No.

A. Introduction:

My name is .... from the city of .... We sent you a letter concerning a survey which the city is conducting. Did you receive the letter? (Show copy of letter if necessary.) As we mentioned in the letter, the purpose of this survey is to determine attitudes of residents toward the physical conditions of the neighborhoods in which they live.

Your household has been chosen to represent families in your area.

The information you give me will be held in strict confidence by the city and your name will in no way be attached to the findings of this study.

We greatly appreciate your participation in this survey.

B. Nuisance Questions

1. In general how satisfied are you with your neighborhood?

____

C5 2. Can you think of anything in your neighborhood which has been particularly annoying or bothersome to you?
1 no 2 yes*

C6
C7

*IF "YES" ASK:	Would you describe it to me? ______________________________ ______________________________ ______________________________ PROBE: ________________________
READ TO RESPONDENT:	I have some questions which will have alternate answers. First I will read the question, and then I will read some alternative answers, and I would like you to choose one answer for each question. For example: If I again asked you the question,

C8 3. How satisfied would you say you are with your neighborhood? The possible answers would be:
1 Very satisfied 2 Somewhat satisfied 3 Not at all satisfied
Would you please choose one of these answers.

READ TO RESPONDENT:	Now I would like to ask you a few questions about some specific potential nuisances which you may have noticed in your neighborhood in the past twelve months, such as: dust, noise, rodents, unsightly premises, odors, flies, and other insects.

C9 4. Within the past twelve months, have you been annoyed by any dust in the neighborhood?

1 No 2 Yes*

C9 IF "YES" ASK:

Would you say you noticed the dust?

3 Very rarely
4 Sometimes
5 Often
6 Most of the time

C10

Were you annoyed?

1 Slightly
2 Moderately
3 Seriously
4 Extremely

C11 IF ANY DUST ASK:

What seems to be the source of the dust?

C12

Did you notice the dust more any particular time of day?

1 No 2 Yes*

IF "YES" ASK:

3 Morning
4 Afternoon
5 Evening

C12

Is there any season of the year that dust is more of a problem?

6 No 7 Yes*

IF "YES" ASK:

8 Winter
9 Spring
0 Summer
11 Fall

C13 5. Within the past twelve months, have you been annoyed by any noise in the neighborhood?

1 No 2 Yes*

*IF "YES" ASK:

Would you say you have noticed the noises?

3 Very rarely
4 Sometimes
5 Often
6 Most of the time

C14

Were you annoyed?

1 Slightly
2 Moderately
3 Seriously
4 Extremely

C15 IF ANY NOISES ASK: What seems to be the source of the noises?

____

____

C16 Did you notice the noises more any particular time of day?

1 No 2 Yes*

*IF "YES" ASK:

3 Morning
4 Afternoon
5 Evening

C16 Is there any particular season of the year that noise is more of a problem?

6 No 7 Yes*

*IF "YES" ASK:

8 Winter
9 Spring
0 Summer
11 Fall

C17 6. Within the past twelve months, have you been annoyed by any rodents in the neighborhood, such as: rats, mice and gophers?

1 No 2 Yes*

*IF YES ASK: Would you say you have noticed the rodents?

3 Very rarely
4 Sometimes
5 Often
6 Most of the time

C18 Were you annoyed?

1 Slightly
2 Moderately
3 Seriously
4 Extremely

C19 IF ANY RODENTS ASK: What seems to be the source of the rodents?

____

____

C20 Is there any particular season of the year that rodents are more of a problem?

1 No 2 Yes*

*IF "YES" ASK:

3 Winter
4 Spring
5 Summer
6 Fall

C21 7. Within the past twelve months, have you been annoyed by any unsightly premises in the neighborhood?
__1__ No __2__ Yes*

*IF "YES" ASK:

Would you say you have noticed the unsightly premises?
__3__ Very rarely
__4__ Sometimes
__5__ Often
__6__ Most of the time

C22 Were you annoyed?
__1__ Slightly
__2__ Moderately
__3__ Seriously
__4__ Extremely

IF ANY UNSIGHTLY PREMISES ASK:

C23 What is the unsightly premises?____________
____

C24 8. Withint the past twelve months, have you been annoyed by any odors in the neighborhood?
__1__ No __2__ Yes*

*IF "YES" ASK:

Would you say you have noticed the odors?
__3__ Very rarely
__4__ Sometimes
__5__ Often
__6__ Most of the time

C25 Were you annoyed?
__1__ Slightly
__2__ Moderately
__3__ Seriously
__4__ Extremely

C26 IF ANY ODORS ASK: What seems to be the source of the odors?
____
____

C27 Did you notice the odors more any particular time of day?
__1__ No __2__ Yes*

*IF "YES" ASK:

__3__ Morning
__4__ Afternoon
__5__ Evening

Is there any season of the year that odors are more of a problem?
__6__ No __7__ Yes*

*IF "YES" ASK:

_8_ Winter
_9_ Spring
_0_ Summer
_11_ Fall

C28 9. Within the past twelve months, have you been annoyed by any flies in the neighborhood?
_1_No _2_Yes*

*IF "YES" ASK:

Would you say you have noticed the flies?
_3_ Very rarely
_4_ Sometimes
_5_ Often
_6_ Most of the time

C29 Were you annoyed?
_1_ Slightly
_2_ Moderately
_3_ Seriously
_4_ Extremely

C30 IF ANY FLIES ASK: What seems to be the source of the flies?
____
____

C31 Did you notice the flies more any particular time of the day?
_1_No _2_Yes*

*IF "YES" ASK:

_3_ Morning
_4_ Afternoon
_5_ Evening

C31 Is there any season of the year that flies are more of a problem?
_6_No _7_Yes*

*IF "YES" ASK:

_8_ Winter
_9_ Spring
_0_ Summer
_11_ Fall

C32 10. Within the past twelve months, have you been annoyed by any other insects in the neighborhood?
_1_No _2_Yes*

*IF "YES" ASK:

What types of insects were they?______________
Would you say you have noticed other insects?
_3_ Very rarely
_4_ Sometimes
_5_ Often
_6_ Most of the time

C33

Were you annoyed?
1 Slightly
2 Moderately
3 Seriously
4 Extremely

IF ANY OTHER INSECTS ASK:

C34

What seems to be the source of the other insects?______________________________
____

C35

Did you notice the other insects more any particular time of day?
1 No 2 Yes*

*IF "YES" ASK:

3 Morning
4 Afternoon
5 Evening

Is there any season of the year the other insects are more of a problem?
6 No 7 Yes*

*IF "YES" ASK:

C35

8 Winter
9 Spring
0 Summer
11 Fall

C36 11. Within the past twelve months, have you noticed any other nuisances in the neighborhood?
1 No** 2 Yes*

C37

*IF "YES" ASK:

What seems to be the source of the nuisances?______________________________
____

C38

**IF "NO" REMIND RESPONDENT OF ANNOYANCES MENTIONED IN QUESTION B, 2.

Would you say you have noticed this nuisance?
1 Very rarely
2 Sometimes
3 Often
4 Most of the time

Would you say that you were annoyed?
5 Slightly
6 Moderately
7 Seriously
8 Extremely

C39

Have you noticed this nuisance more any particular time of day?
___1___ No ___2___ Yes*

___3___ Morning
___4___ Afternoon
___5___ Evening

Is there any season of the year that this nuisance is more of a problem?
___6___ No ___7___ Yes*

*IF "YES" ASK:

___8___ Winter
___9___ Spring
___0___ Summer
___11___ Fall

12. Of the bothersome things you have mentioned, which annoys you:

C40
C41
C42
C43

REPEAT TO RESPONDENT ALL ANNOYANCES MENTIONED

Most________________
Second most____________
Third most_____________
Fourth most____________

C. Direct questions about the dairy.

C44 1. Is there a dairy in this neighborhood?
___1___ No* ___2___ Yes**

*IF "NO" ASK:

Would you move into a house where you had a dairy next door to you?
___3___ No* ___4___ Yes

C45

*IF "NO" ASK:

What would be your objections?____________
____
____

C46

Would you move anywhere into a neighborhood that contained a dairy?
___1___ No* ___2___ Yes

*IF "NO" ASK:

C47

What would be your objections?____________
____
____

C48

**IF "YES" ASK:

Have you ever thought of moving out of the neighborhood because of the dairy?
___1___ No ___2___ Yes

C49 Do you have any objection to the dairy?
___1___ No ___2___ Yes*

*IF "YES" ASK:

C50 What would be your objections?____________

____

____

C51 What is your greatest objection to the dairy?______________________

IF ANY OBJECTIONS ASK:

C52 2. This next question will require you to use your imagination a little.

Suppose scientists in the future were able to completely eliminate all insects, odors, and unsightly premises at all the dairies.

Suppose in this future time you wanted to buy a certain home, but before you bought the home you discovered it was next door to one of these new scientific dairies.

Would you still buy the home?
___1___ No* ___2___ Yes

*IF "NO" ASK:

What would be your objection?____________

____

Under the same circumstances we just mentioned, suppose you discovered that the new scientific dairy was not next door, but just around in the neighborhood somewhere, would you still buy the home in this case?
___3___ No* ___4___ Yes

*IF "NO" ASK:

C53 What would be your objection?____________

____

C54 3. Have you yourself ever lived on a farm, ranch or dairy?
___1___ No ___2___ Yes*

C55 *IF "YES" ASK: How long did you live there?______Years

D. History of Resident.

C56 1. About how long have you lived at this address?______________________

C57 2. Are you renting or do you own your own home?
___1___ Rent ___2___ Own or buying

C58 3. Do you have any children under the age of 18?
___1___ No ___2___ Yes*

C59 *IF "YES" ASK: What are their ages________________

C60 4. Does your property have a back patio?
1 No 2 Yes*

C61 *IF "YES" ASK: Is your patio
1 Uncovered
2 Roofed over
3 Screened in

C62 5. What is the highest grade you completed in school?______________

C63 6. What is your occupation?______________________________

C64 7. What industry are you associated with?____________________

C65 8. What is your spouse's occupation?________________________

C66 9. What industry is your spouse associated with?______________

E. Detail Information.

1. Address____

C67 2. Property value:
1 10 - 14,999
2 15 - 19,999
3 20 - 24,999
4 25 - 29,999
5 30 - 34,999
6 35 - 39,999
7 40 and over

C68 3. Distance from dairy to house______________________________

C69 4. Direction of house to dairy:
1 N 2 NE 3 E 4 SE 5 S 6 SW 7 W 8 NW

C70 5. Front screen door.
1 No 2 Yes

C71 6. House is "L" shaped?
1 No 2 Yes*

*IF "YES" DIRECTION IT BLOCKS: __________

C71
3 SW
4 SE
5 NW
6 NE

C72 7. Back of house faces
1 N
2 S
3 E
4 W

C73 8. Sex of respondent.
__1__M __2__F

C74 9. Type of dwelling.
__1__ single with acreage
__2__ single on city lot

C75 10. Color of house____________________

11. Total D.K. and no response______________

12. Study number____________

13. Interviewer's name__________________________

CITY OF
GARDEN GROVE
CALIFORNIA

City Hall . 11391 Acacia Street . Area Code 714--537-4200

Dear Fellow Citizen:

In the near future, Mr. Stan Fernow, a representative for the City of Garden Grove, will call at your home. Mr. Fernow is conducting a survey to determine the attitudes of residents toward the physical conditions of the neighborhoods in which they live.

Any information you may wish to give will be most appreciated and will be held in strict confidence. Your name will in no way be attached to the findings of this survey.

The results of the survey will provide us with needed information which will help to make our city a better place in which to live. We will be sincerely grateful for your participation. If you have any questions, please do not hesitate to call my office.

Very truly yours,

s/

DUDLEY N. LAPHAM
City Manager

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APPENDIX 2

ENTOMOLOGICAL STUDY
FOR
COMPARISON OF FLY PRODUCTION AT TYPICAL, CONVENTIONAL EARTH CORRAL DAIRIES WITH WATER-FLUSHED, ALL-CONCRETE DAIRIES

by

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APPENDIX 2

INTRODUCTION

The purpose of this study was to entomologically compare conventional dairies with flush-out dairies. The aims were: (1) to compare their similar operational features and numerically evaluate them for fly development, and (2) to determine what engineering and management factors affected fly development in the operation of flush-out dairies.

METHODS

The following four dairies in San Bernardino County near the communities of Ontario and Chino were selected for the study:

Conventional Dairies:

1. Ormonde Dairy, 14510 Archibald Ave., Ontario
2. Swager Dairy, 8485 Edison Ave., Chino

Flush-out Dairies:

3. Cloo Dairy, 14848 Haven Ave., Chino
4. Shade Grove Dairy, 13485 Bon View Ave., Ontario

Methods Employed

The dairies were evaluated on May 21 and 29, June 9 and 29, July 15, and August 13, 1970. During these inspections, emphasis was placed on the areas, cause, and degree of fly development, but not as to species. The following areas were evaluated for fly development in respect to conventional dairies versus flush-out dairies: barn wash (dam area), corrals (free-stalls and alley lanes), fence lines (side walls and islands), feeding areas (same), water troughs (same), and sump areas (same). (See Form 1).

The fly developmental sources were numerically evaluated by examining approximately 1-foot square-areas of manure. The following numerical system was used to evaluate the degree of fly development found during these inspections: 0 (no fly development), 5 (less than five larvae and pupae), 10 (more than five larvae and pupae found), and 20 (excessive larvae and pupae found). (See Table 19 for data collected).

Observed Fly Breeding Sources

Barn Wash (Dammed area). In the conventional earth corral dairies, important fly development areas were the sides adjacent to the fence lines below the barn wash facilities. These areas allowed for continuous fly development. Good management practices such as weekly removal of manure or stirring to facilitate drying of manure would reduce such fly developmental sources.

The principal areas of fly development at the flush-out dairies were the islands between the lanes below the dammed areas. Providing higher side walls and more volume of water or a greater velocity could prevent manure from accumulating and prevent the fly development situations.

Corrals (Free-stall and alley lanes). In the conventional dairies the areas where fly development occurred were where the manure was allowed to collect adjacent to the fence lines, in the corners, and in the centers of corrals. Urine-soaked areas also supported fly development. These areas allowed for continuous fly development greater than as the flush-out dairies. Good management practices such as weekly disking of corrals to facilitate drying of manure and removal of manure accumulation in corral corners and centers would reduce such fly developmental sources.

Fly development involving the free-stall and alley lane areas of the flush-out dairies occurred only at the lower ends of the systems, where water surged over into the free-stall spaces, and where manure remained in alley lanes. The providing of higher side walls, and more volumes of water or at a greater velocity of water, would prevent fly development by keeping free-stalls drier and alley lanes free of manure. It was also noted that the number of cows grouped in the alleys and lanes affected the flushing action of the water.

Fence Lines (Side Walls and Islands). The accumulation of manure under fence lines and around posts of conventional dairies allowed for comparatively less fly development than at flush-out dairies. Management practices such as weekly removal of manure, especially near watering and feeding areas, would reduce fly development.

Conversely, the side walls and islands of the flush-out dairies allowed for comparatively greater fly development because of manure collecting on side walls and in island areas between alley lanes. The sloping and coving of the side wall bases and elimination of shelf would prevent these fly development sources. Adequate volumes or water velocities could then move manure more efficiently.

Feeding Areas. In the conventional dairies significant areas for fly development were in and near the feed mangers, adjacent concrete aprons, and some at the bases of the animal stanchions. These areas allowed for greater fly development than at the flush-out dairies. Management practices such as removal or displacement of manure from the above areas, and timely removal of feed wastes from mangers, would reduce these fly developmental sources. Roofing the feeding area to protect from rain, would also be desirable.

The only areas of fly development in feeding areas of flush-out dairies were the feed mangers and the bases of the feeding stanchions. These were placed on concrete aprons and well drained, but roofing of feeding areas, along with timely removal of feed wastes, would further prevent fly development.

Water Troughs. In the conventional dairies the fly development occurred in the peripheral areas and on the side walls of the water trough systems. These areas allowed for continuous fly development greater than the flush-out dairy systems. Weekly removal of manure and avoidance of water overflowage would correct these fly developmental sources.

The flush-out dairy water trough systems were serious and continuous sources for fly development when compared to other areas of evaluation. Raised side walls designed to prevent overflowage would help correct these fly development areas. The design of a full watering trough system located between islands would also accomplish this.

Sump Areas. In the conventional dairies the only pestiferous fly development occurred in the immediate periphery of the barn wash outlets. These areas allowed for less fly development than the flush-out dairy sump systems. Management practices such as periodic manure displacement or disking would help prevent these fly developmental sources.

The sump areas of the flush-out dairies were a greater and continuous source for fly development. The areas of fly development were where the manure surged over the sump facilities, or backed up between the alley lanes, or which ran over their respective sides. These problems could be avoided by adequate side walls, larger pits, and pit entrances, and adequate volumes of water or increased water velocity.

SUMMARY OF DATA

The observations were recorded on Form 1 for each of the six critical fly developing areas of each of the four dairies in the study. The rating scale was as follows:

In each 1-foot square-area of manure observed--

Rating	Condition
0	No fly development
5	One to four larvae or pupae
10	Five to thirty larvae or pupae
20	Over thirty.

Table 19 provides for recording the observations of each of the six potentially critical fly breeding areas on each of the four dairies. Dairies 1 and 2 are conventional earth corral dairies, and 3 and 4 are of the all-concrete, flush-out type.

For each typical area of observation the following information is given:

The first line gives the total number of 1-foot square areas evaluated during the six observation dates over the four-month observation period (warm weather season from May to August.)

The second two lines give the number of sample areas in the specified (in parenthesis) ranking category.

The fourth line ("TOTALS") was obtained as follows: the number of observations which were made in each ranking category were multiplied by the ranking number (shown in parenthesis). The sums of these products are the "TOTALS".

TABLE 19

FLY DEVELOPMENT RATING DATA

AREAS EVALUATED	DAIRY IDENTIFICATION				DATA NUMBERS
	1	2	3	4	
Barn wash (dammed area)	30	30	30	30	Samples No.
	17(0) 6(5)	7(0) 7(5)	18(0) 6(5)	16(0) 14(5)	Ratings No.
	7(10)	15(10) 1(20)	5(10) 1(20)		
	100	205	100	70	TOTALS
Corrals (free-stalls, alleys)	80	56	40	35	Samples No.
	44(0) 23(5)	34(0) 10(5)	32(0) 8(5)	26(0) 7(5)	Ratings No.
	11(10) 2(20)	10(10) 2(20)		2(10)	
	265	190	40	55	TOTALS
Fence lines (side walls, islands)	85	62	48	40	Samples No.
	44(0) 31(5)	31(0) 22(5)	27(0) 11(5)	11(0) 16(5)	Ratings No.
	10(10)	9(10)	10(10)	12(10) 1(20)	
	255	200	155	230	TOTALS
Feeding areas	30	30	30	30	Samples No.
	9(10) 17(5)	10(0) 12(5)	22(0) 7(5)	24(0) 5(5)	Ratings No.
	4(10)	8(10)	1(20)	1(10)	
	125	140	55	35	TOTALS
Water troughs	30	30	30	30	Samples No.
	9(5) 15(10)	12(5) 15(10)	15(0) 6(5)	4(0) 11(5)	Ratings No.
	6(20)	3(20)	7(10) 2(20)	15(10)	
	315	270	140	205	TOTALS
Sump areas	30	30	30	30	Samples No.
	25(0) 3(5)	24(0) 3(5)	18(0) 3(5)	15(0) 5(5)	Ratings No.
	2(10)	3(10)	8(10) 1(20)	13(10) 2(20)	
	35	45	115	195	TOTALS

FORM 1

DAIRY WASTE MANAGEMENT PROJECT - ENTOMOLOGICAL SURVEY

Dairy Name________________________________Date________________

Location______________________________Type of Operation________________

AREAS TO BE EVALUATED (Conventional Flush-Out)	COMMENTS AND FLY DEVELOPMENT RATINGS
A. BARN WASH (DAMMED AREA)	
B. CORRALS (FREE-STALLS, ALLEYS)	
C. FENCE LINES (SIDE WALLS, ISLANDS)	
D. FEEDING AREAS (SAME)	
E. WATER TROUGHS (SAME)	
F. SUMP AREAS (SAME)	

Explanation of Table 20.

The "TOTALS" of Table 19 were divided by the numbers of observations ("Samples No.") to give an "average" ranking for each category of observation area, for each dairy. These were then totaled for each dairy and for each of the two types of dairies. The "ranking" for each dairy was then obtained by dividing the "TOTALS" by the number of observation areas to give "AVERAGES".

TABLE 20

FLY DEVELOPMENT NUMERICAL RATINGS

Areas Evaluated	Dairy Identification					
	1	2	Average 1 + 2	3	4	Average 3 + 4
Barn wash (dammed area)	3.33	6.50	4.92	3.33	2.18	2.75
Corrals (free-stalls, alleys)	3.31	3.39	3.35	1.00	1.57	1.29
Fence Lines (side walls, islands)	3.00	3.23	3.12	3.23	5.75	4.49
Feeding areas	4.17	4.67	4.42	1.83	1.17	1.50
Water troughs	10.50	9.00	9.75	4.67	6.83	5.75
Sump areas	1.17	1.50	1.34	3.83	6.50	5.17
TOTALS	25.48	28.29	26.90	17.89	24.00	20.95
AVERAGES	4.35	4.72	4.48	2.98	4.00	3.49

TABLE 21

PERCENT OF SAMPLES WITH FLY DEVELOPMENT

Areas Evaluated	Dairy Identification					
	1	2	Average 1 + 2	3	4	Average 3 + 4
Barn wash (dammed area)	43	77	60	40	46	43
Corrals (free-stalls, alleys)	45	41	43	20	26	23
Fence lines (side walls, islands)	48	50	49	44	70	57
Feeding areas	70	67	68	27	20	23
Water troughs	70	60	65	50	87	68
Sump areas	16	20	18	40	50	45
TOTALS	292	315	303	221	299	259
AVERAGES	48.66	52.50	50.50	36.83	49.83	43.16

DISCUSSION AND RESULTS

The overall numerical ratings for fly development were light, as shown in Tables 20 and 21, and were less for the flush-out dairies than for the conventional dairies. But when evaluating comparative areas there was more fly development in the sump areas and side wall and island areas of the flush-out dairies than at earth corral dairies. Both dairy operations had the highest fly development in the areas near water troughs.

APPENDIX 3

ENTOMOLOGY REPORT

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